LEGAL INSTRUMENTS FOR THE PREVENTION AND MANAGEMENT OF DISPOSAL AND LOSS OF FISHING GEAR AT SEA

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1.0. INTRODUCTION

In the early-1980s, concern heightened over the impacts of persistent garbage and debris in the world's oceans on marine flora and fauna and on various human activities. Subsequently, three international conferences and workshops were convened (1984, 1989, 1994) to define the scope and magnitude of the marine debris issue (Shomura and Yoshida, 1984; Shomura and Godfrey, 1990; Coe and Rogers, 1997) and to consider appropriate monitoring, educational, and regulatory responses. A major theme of another international symposium on ocean disposal in 1986 was also the disposal or loss from ships at sea of plastics and other persistent synthetic materials (including fishing nets) and its impacts on marine life (Wolfe, 1987). The consistent outcome of these meetings was the recognition that persistent marine debris, particularly discarded or lost fishing gear, was causing substantial harm to a large variety and number of marine animals when they either ingested or became entangled in it, and posing operational risks to recreational and commercial marine traffic.

In 1984 when the First International Conference on Marine Debris was convened, a number of multilateral and bilateral international agreements or conventions force that regulated disposal into the oceans of some forms of garbage were in. All but one, however, were regional instruments. That one, the London Dumping Convention, arguably regulated only the deliberate disposal at sea of various kinds of garbage that were generated on land. Most of the regional agreements did include provisions to generally prohibit the disposal of persistent plastic and other synthetic materials at-sea. However, these were not bright-line prohibitions. Rather, they contained key exceptions that made the agreements ineffective in regulating disposal or discard of the types of persistent marine debris, fishing gear of various sorts, that are a principle concern for conservation of living marine resources and the focus of the International Marine Debris Conference in Hawai'i in August 2000.

Not until 1988 was there a global agreement in force that addressed discharge of pollution from sources that were other than land-based. This instrument took initial form in 1973 as the International Convention for the Prevention of Pollution from Ships. It was later modified and incorporated into its substantive Protocol in 1978 and then entered into force generally on October 2, 1988. It has become known as MARPOL 73/78 and it consists of twenty Articles, two Protocols, and six Annexes.

Another important recent global agreement, which contains a number of provisions relevant to disposal of various substances by ships at sea, is the United Nations Convention on the Law of the Sea (UNCLOS). Although concluded in 1982 this convention did not enter into force until November 16, 1994.

The London Dumping Convention, MARPOL 73/78, UNCLOS, and the Convention on the Intergovernmental Maritime Consultative Organization (CIMCO, 1948, 9 U.S.T 621, T.I.A.S. 4044) all contain general obligations for the Parties to promote cooperation with regional organizations and to assist developing states in protecting the marine environment. Moreover, two key aspirational principles of the United Nations Conference on the Human Environment (Stockholm Conference of 1972) called on all states to take all possible steps to prevent pollution of the world's oceans and to condition their sovereign rights to exploit resources within their jurisdiction by a responsibility to avoid damage to the resources within the jurisdictions of other states and in areas beyond the limits of national jurisdiction.

Here we briefly: (1) review the provisions of these global international instruments relevant to the prevention and regulation of the discharge, disposal, and accidental discard of fishing gear by ships at sea, (2) highlight some domestic laws which regulate the same in state waters, and (3) raise issues for dialogue on preventing discharge, complying with discharge prohibitions, complying with ship-based and port-based retention and processing, and monitoring the dynamics of derelict fishing gear.

2.0. INTERNATIONAL LEGAL INSTRUMENTS

2.1. MARPOL 73/78

This treaty establishes specific regulations governing the discharge of pollution and wastes from ships at sea. Annex V regulates the disposal of ship-generated "garbage." It provides guidelines regarding whether, where, and how such garbage may be discharged into the ocean. It prohibits the deliberate (but not necessarily unintentional) discharge of all plastics, including synthetic fishing nets, and non-food garbage into the ocean. And it requires Parties to provide garbage receptacles at their ports for the disposal of garbage that is generated by ships while at sea. The provisions in Annex V are optional obligations under MARPOL. States that ratify MARPOL 73/78 are not consensually bound to Annex V's obligations until they also specifically ratify the Annex. As of 30 April 2000, ninety-six countries, accounting for about 94% of the world's merchant fleet tonnage, were Parties to Annex V; most of these are still developing programs to implement the Annex domestically as it is not self-executing in most of those countries. Key to our discussion here and the focus of concern, however, is that the prohibitions of Annex V is read to

primarily apply to merchant fleets with less emphasis given to its application specifically to commercial fishing vessels. Nonetheless, Annex V does prohibit the dumping of plastics and synthetic ropes and fishing gear at sea and also regulates the dumping of other types of ship-generated garbage at sea.

The Annex applies to all vessels registered to Parties and includes a general prohibition of the disposal of 'garbage' in most areas, with some permitted exceptions. Garbage is defined as "all kinds of victual, domestic, and operational waste excluding fresh fish and parts thereof, generated during the normal operation of the ship and liable to be disposed of continuously or periodically except those substances which are defined or listed in other Annexes to the present Convention." The deliberate disposal of plastics is absolutely prohibited; plastics are defined as including "but not limited to synthetic ropes, synthetic fishing nets and plastic garbage bags." Parties to Annex V must ensure that marinas, ports, or terminals provide adequate port reception facilities for garbage whose disposal at sea is prohibited.

There are three exceptions to the disposal requirements of Annex V:

(1) when the disposal of garbage at sea is necessary for securing the safety of the vessel, its crew, or other lives at sea;

(2) the disposal was caused by damage to the ship or its equipment, provided that all reasonable precautions have been taken before or after to prevent or minimize the escape; and

(3) the loss of synthetic fishing nets or synthetic material incidental to their repair was accidental, provided that all reasonable precautions have been taken to prevent such loss.

In 1989 paragraph (c) of Annex V was amended to read "the accidental loss of synthetic fishing nets, provided that all reasonable precautions have been taken to prevent such loss." This change strengthens Annex V by narrowing the application of this exception to just the loss of synthetic fishing nets. Therefore, the loss of net pieces or fragments incidental to net repair, even if accidental and reasonable precautions had been taken, is arguably no longer exempt from the general prohibition of discharge.

The International Maritime Organization (IMO) is the agency responsible for promoting the MARPOL convention. A primary function of the IMO has become the prevention and control of marine pollution from ships. Moreover, the IMO is identified by UNCLOS (Article 211) as the organization that is presumed to authorize the establishment of marine pollution standards. The IMO does have the power to recommend regulations under MARPOL, though it lacks the power to impose those regulations. Imposition of standards is left to the individual states directly or indirectly through regional organizations that are delegated such authority.

Under MARPOL, Parties have a general obligation to capture and prosecute those who violate domestic laws that implement the provisions of the agreement. The monitoring and enforcement provisions of MARPOL 73/78 include two components: one applying to port states and another to flag states. A port state has an affirmative duty and right to monitor and inspect vessels as they enter its jurisdiction. A flag state has a duty and right to investigate an alleged violation by a vessel flying its flag and take necessary enforcement actions against the ship. In addition, as will be discussed in the next section, flag states have a duty under the 1982 Convention on the Law of the Sea (Article 94) to ensure that vessels flying their flag observe and take measures which conform to all the applicable international regulations concerning the prevention, reduction, and control of marine pollution.

For inspections of discharge violations, a party to MARPOL does not need "clear grounds"to proceed. A Party to MARPOL 73/78 may also inspect a vessel to which the convention applies when it enters a port or off-shore terminal under its jurisdiction if another Party has requested an investigation and has provided sufficient evidence that the vessel has discharged harmful substances or effluents in violation of the Regulations. If an inspection by the port state or Party indicates that a vessel has violated the convention, the port state or party must provide the government of the flag state of the vessel with a report and evidence of the alleged violation. The government of the flag state must then investigate the alleged violation. It may request additional or better evidence from the port state or party that alleges the violation and then begin proceedings over the violation in accordance with its laws if the evidence is suitably demonstrative. The government of the flag state must also promptly inform the port state or party that reports the violation and the IMO of any action taken.

Consequently, a state that is a party to MARPOL may generally inspect a foreign vessel as it enters its jurisdiction. If MARPOL violations are found, the party must document them and refer the case to the flag state of the vessel for investigation and enforcement action. The flag state is required to investigate the allegations, take enforcement action (if necessary), and inform the Party reporting the violation of the action taken. Furthermore, Article 4(4) states that the law of Parties regarding violations of the requirements of MARPOL shall specify penalties that are "adequate in severity to discourage violations of the present Convention and shall be equally severe irrespective of where the violations occur." Therefore, a flag state or a port state must not allow for more lenient treatment of vessels flying its flag or apply different penalties based on where the violation occurred.

A Party to MARPOL, which has adopted its own laws and regulations pursuant to the requirements of this convention, may also "cause proceedings to be taken in accordance with its law" when a violation occurs within its jurisdiction or furnish the evidence of the violation to the government of the vessel (Article 4[2(a)(b)]).

Article 11 of the Convention requires all Parties to communicate certain information to the IMO, including the text of laws adopted pursuant to the matters covered by the Convention. This provision not only institutionalizes transparency, but it also allows other Parties to see what enforcement procedures and possible penalties for MARPOL violations exist in other nations. This provision provides an opportunity for Parties to determine if,

in fact, other Parties to MARPOL are specifying penalties that are "adequate in severity to discourage violations of the present Convention and shall be equally severe irrespective of where the violations occur," as required under Article 4(4). However, all Parties do not or have not complied with this provision of MARPOL and there is no regular agenda item to address compliance with Article 11.

Annex V was amended in 1995 to greatly enhance port state powers to enforce MARPOL regulations. Regulation 8 provides that a port state can inspect and prevent from sailing a vessel from when there are "clear grounds for believing that the master or crew are not familiar with essential shipboard procedures relating to the prevention of pollution by garbage." A port state can require that such a vessel remain docked until it has come into compliance with the requirements of Annex V. Also in 1995, the IMO Assembly adopted Resolution A.787(19) "Procedures for Port State Control." This resolution outlines the procedures for port state control of operational requirements related to the safety of ships and prevention of pollution. Moreover, amendments to it in 1999 provide detailed guidelines, recommendations, and definitions for procedural conduct by port states for what actions may be taken, and for how results should be.

The resolution also includes guidelines for when and how more detailed investigations and inspections can be carried out pursuant to the discharge requirements of Annexes I and II, but not Annex V. The guidelines for control of operational requirements address how it may be determined that all of the operational requirements of Annex V have been met. For example, the Port State Control Officer (PSCO) may check certain on-board operational requirements, including garbage requirements under Annex V. However, when exercising the controls "recommended" by the guidelines "the PSCO should not include any operational tests or impose physical demands, which, in the judgement of the master, could jeopardize the safety of the ship, crew, passengers control officers or cargo." Furthermore, the PSCO "should ensure, as far as possible, no interference with normal shipboard operations… nor should the PSCO require demonstration of operational aspects which would unnecessarily delay the ship." Unlike the procedures established for Annex I and II, these guidelines require that the PSCO "exercise professional judgement" to determine if the vessel is operationally fit to sail without being a threat to the ship, persons on board, or an "unreasonable threat of harm to the marine environment." There is no chapter that sets out what the port state action could be based on a PSCO investigation, other than the actions provided for in the Convention (Article 6), like there is for Annex I and II.

The IMO has promulgated guidelines for the implementation of Annex V, but they are generally limited to establishing the conditions under which garbage may be disposed of at sea and to specifically defining garbage. Certain kinds of "cargo residues" are not explicitly excluded from being disposed as garbage, though it is not clear that this may be relevant to fishing gear. The guidelines do caution however, that these items may nonetheless pose harm to the marine environment but may also not be suitable for disposal at port reception facilities that may be equipped to handle general garbage.

2.2. The 1982 United Nations Convention on the Law of the Sea (UNCLOS)
The principal duties of flag states are clearly identified in Article 94 of UNCLOS. Specifically, a state should not register a vessel and allow it to fly its flag unless it can "effectively exercise its jurisdiction and control in administrative, technical, and social matters over ships flying its flag." The duties of a flag state covered by Article 94 include obligations under generally accepted international regulations, procedures, and practices, such as MARPOL.

States that become Parties to UNCLOS accept as an obligatory condition that they must adopt domestic laws and regulations to prevent, control, and reduce marine pollution. Further, the effects of these measures must be in harmony with generally accepted international rules and standards that have been developed through the competent international organization or general diplomatic conference. Therefore, states that are not a Party to MARPOL are still obliged to adopt laws and standards, which give effect to its provisions, under UNCLOS. Furthermore, states must ensure compliance by vessels flying their flag with applicable international rules and standards, developed by a competent international organization or diplomatic conference, and with their laws and regulations adopted pursuant to UNCLOS for the prevention, reduction, and control of marine pollution from ships. Moreover, states should take measures to implement the applicable international rules and regulations and provide for effective enforcement of these rules, regardless of where the violations may occur. These measures particularly include adopting domestic laws and regulations. Thus, obligations under UNCLOS would appear to bring all fishing fleet nations within the disposal prohibition framework of MARPOL Annex V.

UNCLOS also clarified the major difficulty of the MARPOL convention for determining who has authority and jurisdiction to investigate and prosecute pollution violators by codifying the duties and powers of states to protect the flag state. Each state is required to ensure that vessels flying its flag or carrying its registry comply with pertinent international rules and standards. It is the primary response of port and coastal states to detect a ship's violation of these rules and standards and to inform the ship's flag state of the violation, even though it is recognized that flag states may generally be reluctant to prosecute vessels flying their flag. Enhanced port state enforcement abilities as provided by international agreement will undoubtedly promote the effectiveness of such otherwise voluntary compliance by flag states.

In November 1999, the IMO Assembly passed a resolution on the self-assessment of flag-state performance, which includes a self-assessment form. This resolution asserts that flag states have the principal responsibility to have an adequate and effective system in place to exercise jurisdiction and control over vessels entitled to fly their flag and to ensure these vessels adhere to the relevant international rules and regulations. The "Flag State Performance Self-Assessment Form" is intended to establish a uniform set of internal and external criteria which can be voluntarily used by flag states to gauge how well their maritime administrations are functioning and to assess their own performance as flag states. The resolution urges member governments to complete a self-assessment of their capabilities and performance in implementing and complying with the various

instruments to which they are Party. It also encourages member governments to use the self-assessment form when requesting technical assistance from or through IMO. However, submission of a completed form is voluntary and is not a prerequisite for receiving technical assistance. The resolution requests that member governments submit a copy of their self-assessment report so that a database that would assist IMO in establishing its efforts to achieve consistent and effective implementation of IMO instruments.

3.0. DOMESTIC IMPLEMENTATION OF ANNEX V OF MARPOL 73/78

3.1. United States

The U.S. Ocean Dumping Act implements the London Dumping Convention regarding the at-sea disposal of land-generated wastes. The Ocean Dumping Act narrows the exemptions of the London Dumping Convention however to only the discharge of effluents that are incidental to the propulsion or operation of motor-driven equipment or vessels as opposed to matter that is incidental to the "normal operations of vessels."

Regarding the discharge of vessel-source garbage and fishing gear at sea, the U.S. Act to Prevent Pollution from Ships of 1982 (APPS) was specifically enacted to implement the relevant provisions of MARPOL 73/78, including an amendment to include the application of Annex V when it entered into force. The APPS/MPPRCA applies to: (1) a U.S. flagged vessel wherever it is located in the world's oceans, and (2) to all vessels while in the navigable waters or EEZ of the United States. U.S. regulations follow Annex V in that they require the person in charge of a vessel to keep a detailed log of the discharge and disposal of solid waste, including plastics, and to develop a waste management plan. These records must be maintained by the vessel for at least two years and be available for inspection. Vessels must also display pollution prevention placards. Penalties for violations under MPPRCA include civil penalties of $25,000 per day per violation; criminal penalties of $50,000 and five years in prison; and denied access to U.S. ports, terminals, and marinas. In 1998 the U.S. Coast Guard reported 219 violations of the MPPRCA and imposed nearly $500,000 in penalties. Of these 219 cases, 57 were fishing vessels and 90 were recreational vessels.

In 1992, the United States informed the IMO of change in United States enforcement policy regarding ships in U.S. ports suspected of Annex V violations occurring within the U.S. Exclusive Economic Zone (EEZ). As a result of the history of low numbers of flag states responding regarding a reported violation (pursuant to MARPOL 73/78), the United States notified IMO that it "will take direct enforcement action consistent with all international law principles against ships in the United States ports for all suspected Annex V violations that have occurred with the United States 200 mile Exclusive Economic Zone."

3.2. People's Republic of China

The People's Republic of China is a party to MARPOL and Annex V. The requirements of MARPOL and Annex V are implemented by Ministry level regulation and are enforced by the Maritime Safety Administration. Under these regulations, all vessels registered in China and flying a Chinese flag are required to designate a person responsible for the disposal of garbage, have a garbage plant, and maintain garbage disposal records. Both the shipping companies and the vessel's masters are held accountable for adhering to the

requirements of Annex V. Maritime Safety Administration inspectors enforce Annex V regulations on Chinese flagged vessels, but do not inspect foreign flagged vessels for Annex V compliance. In addition, the Maritime Safety Administration implements and enforces Annex V regulations on the high seas, in Chinese coastal waters, and on the Yangtze River. An interagency committee coordinates enforcement on the Yangtze River because several Ministries have jurisdiction over the Yangtze River.

3.3. Republic of Korea

The Republic of Korea is a party to MARPOL and Annex V. To implement the provisions of Annex V, Korea enacted the Marine Pollution Prevention Act in 1994, as the implementing ministerial decree. The law and decree incorporate the suggested language of Annex V, including the language defining the types of garbage covered by the Act. The law includes the following enforcement provisions:

- In instances of insufficient record keeping—a fine of up to one million Korean won (approximately $900 U.S.).
- Intentional throwing of waste into the ocean—a fine up to 20 million Korean won, or up to three years in prison.
- Unintentional throwing of waste into ocean—a fine of up to 10 million Korean won, or up to one year in prison.

The Maritime Police Authority is responsible for enforcement of the Act, turning cases over to the prosecutor's office for prosecution.

4.0. IMPLEMENTATION CHALLENGES AND WEAKNESSES OF MARPOL

4.1. MARPOL is a UN Agreement

MARPOL was concluded under the auspices of the International Maritime Organization, which also handles its administration. Due to this relationship, non-state entities, such as Taiwan cannot become a party to MARPOL or any of its Annexes. Taiwan has the sixth largest fishing fleet in the world (and the second largest fleet in the central and western Pacific Ocean) so its inability to be legally bound to the provisions of MARPOL and its Annexes weakens the effectiveness of the Agreement. Under these circumstances, such fishing entities could consent to unilaterally implement MARPOL, but this is not the optimal solution.

However, despite its inability to become a party to MARPOL or its annexes, Taiwan has taken steps to address the marine debris problem it is experiencing in its own marine habitats (e.g., coral reefs). Taiwan is drafting a marine pollution prevention law, which will contain provisions that discourage ships from discarding nets and other types of debris at sea and amendments to its Fisheries Act to increase the protection of marine resources.

4.2. Non-Parties

The activities of non-Parties to the Agreement and its optional Annexes weaken MARPOL. Non-Parties are not legally bound to abide by the provisions. Of the ninety-six present Parties to Annex V, nearly all of the nations with fishing fleets operating in the northern Pacific region are party to Annex V, except for Taiwan (see section 4.1) and the Philippines.

In this case, it appears, that non-Parties to MARPOL and Annex V are less of a problem then the effective implementation and enforcement of the provisions of Annex V by Parties operating fishing vessels in the Pacific region.

4.3. Lack of Capacity and Infrastructure to Comply with MARPOL Requirements

One significant obstacle to states becoming a party to MARPOL, or any of the optional Annexes, or adopting laws that have the same effect as generally accepted international rules and standards (as required under UNCLOS III), is the institutional capacity required to fully and effectively implement the regulations and provisions of the Agreement and its Annexes (i.e., enforcement, administration, and infrastructure). Understandably, states do not want to accept obligations that they may not meet. Increasing the capacity of states to comply with the regulations of MARPOL and its Annexes will not only encourage their ratification of the Agreement but also increase its effective implementation. This is especially important for small island and developing states. Joint development projects between intergovernmental organizations and donor institutions, such as the IMO-World Bank Wider Caribbean Initiative, could help to overcome this obstacle. This would also increase the number of Parties to the Agreement and promote effective implementation.

4.4. Enforceability

Due to the nature of fishing and marine transport operations, vessels spend a significant portion of their time far out to sea or on the high seas. The enforcement of regulations by States becomes very difficult in this case. Vessels must be observed violating the regulations or there must be some other type of clear evidence that can be attributed to that particular vessel to initiate enforcement proceedings. Methods of identifying the source of derelict fishing gear, which may have been either lost or intentionally discarded, could assist flag State enforcement efforts and the detection of violations by other Parties.

4.5. Penalty Action

MARPOL itself does not specify any penalties for violations of its Regulations. Parties are required to investigate alleged violations and, given sufficient evidence, initiate proceedings against the vessel. If found guilty of a violation of a MARPOL Regulation, MARPOL states that the law of Parties shall specify penalties that are "adequate in severity to discourage violations of the present Convention and shall be equally severe irrespective of where the violations occur." This allows a Party to develop a penalty scheme according to its law. However, MARPOL could be strengthened if it identified the types of penalties that should be imposed by Parties when a violation occurs. A range of penalty options for violations of increasing severity could be developed. This would help to standardize the types of penalties among Parties for specific categories of violations so that any penalties imposed are in fact "adequate in severity to discourage violations of the present Convention and shall be equally severe irrespective of where the violations occur." Moreover, IMO's efforts could be particularly enhanced if Parties would make available copies of domestic laws which have been adopted to implement the Convention (as required by Article 11).

5.0. REGIONAL FISHERIES MANAGEMENT ORGANIZATIONS (RFOs)

Fisheries that extend beyond the exclusive jurisdiction of one state, such as straddling fish stocks and highly migratory fish stocks, are most often managed by regional fisheries organizations or commissions established by multilateral agreements. In the Pacific there are two, the Inter-American Tropical Tuna Commission (IATTC) and the North Pacific Anadromous Fisheries Commission (NPAFC), and one under negotiation for the central and western pacific (referred to as the MHLC). These regional fisheries organizations could play an important role in trying to eliminate the discard of fishing gear and related debris.

RFOs and their members have a duty to comply with relevant international law and agreed upon standards, such as UNCLOS and the Food and Agriculture Organization's Code of Conduct for Responsible Fisheries. One of the general principles of the Code of Conduct is that the "harvesting, handling, processing, and distribution of fish and fishery products should be carried out in a manner which will… minimize negative impacts on the environment." The Code of Conduct has several provisions which assert that States and subregional or regional fisheries management organizations or arrangements should adopt appropriate measures to minimize catch by lost or abandoned fishing gear and its impact on non-target species, in particular endangered species (Article 7.2 [f][g]; Article 7.6.9), and that fishing activities ought to be conducted with due regard for the IMO requirements relating to the protection of the marine environment and the loss of fishing gear (Article 8.4.1; Article 8.7.1).

Therefore, RFOs should have among their mandates and binding conservation rules a prohibition on discarding gear, light-sticks, or other types of material related to fishing activities, which apply to its members fishing within its regulatory area. By expanding its mandate to include prohibitions on discarding fishing gear, RFOs will more fully implement the Code of Conduct and help to ensure that the requirements of IMO are more widely implemented and enforced. In addition, implementation of these requirements by RFOs (depending on their membership) could capture fishing vessels that otherwise could not be legally bound to the provisions of MARPOL Annex V (e.g., Taiwan).

6.0. SUMMARY

A number of international legal instruments are now in force which have various effects in limiting the discharge of persistent fishing gear and fishing gear fragments into the marine environment. Among the global instruments, the London Dumping Convention of 1972 regulates the deliberate disposal at sea of garbage and persistent plastics of land-based or land-generated origin (= "dumping"). MARPOL 73/78, and in particular Annex V to the Protocol to this Convention, addresses the operational and unintentional discharge of vessel-source pollution, including certain fishing gear, persistent plastics and other operational garbage at sea (i.e., ocean "dumping" is not covered by MARPOL 73/78). These instruments therefore act in concert to regulate the input of pollution, including derelict fishing gear, into the world's oceans, though Annex V of MARPOL 73/78 has emerged as the principal legal instrument regulating the disposal by ships at sea of all plastic materials. Certain exemptions or ambiguous definitions of terms, however, have arguably left the discharge of some forms of derelict fishing gear unregulated. UNCLOS also contains several provisions that have direct relevance for regulating discharge of

fishing gear by vessels at sea, though similar loopholes exist. A number of regional international agreements, most notably those within the United Nations Regional Seas Programme, apply to at-sea discharge of fishing gear. The language and terms in those agreements are similar, however, to that in global agreements leading to similar inadequacies in effective governance of reducing the impacts of derelict fishing gear to marine environments and human traffic. Implementation of domestic legislation by Parties to international agreements to govern such impacts coupled with State compliance of both international and domestic legal instruments are key to limiting future burdens to marine environments from the threats of these persistent pollutants. Elimination of the extant burdens through cooperative and collaborative programs, an issue not yet embraced by any of these instruments, is also a key issue for further international dialogue and action.

7.0. RECOMMENDATIONS FOR FURTHER DISCUSSION: OPPORTUNITIES FOR IMPROVEMENT AND ACTIONS NEEDED

- Develop public/private partnerships or enlist the aid of international donor institutions (e.g., the World Bank or the International Monetary Fund) to increase capacity in States, particularly developing states, so they can comply with MARPOL regulations and/or will be in a position to ratify and effectively implement the Convention and its annexes (Example: Wider Caribbean Project).

- Increase the flag state response to alleged violations by other Parties.

- Encourage all Parties to comply with Article 11 of MARPOL and establish an agenda item regarding this provision in the appropriate sub-committee (i.e., the IMO Marine and Environment Protection Committee).

- Enhance the enforcement provisions of MARPOL Annex V or develop new mechanisms to increase compliance with Annex V provisions.

- Parties should encourage those that have not already done so to become a party to MARPOL and/or ratify the optional Annexes.

- Address issues of inadequate reception facilities through development projects.

- Develop programs with positive incentives for proper disposal (e.g., a deposit system for light sticks and other types of plastics).

- Increase the fishing industry's awareness of the navigational hazards and potential economic costs of marine debris (i.e., fouling of props and damage to set nets).

- Strengthen the Port State Control procedures and guidelines for Annex V provisions.

- Encourage Parties to MARPOL to implement strong domestic legislation for regulating intentional and unintentional discharge of fishing gear from vessels either flagged or registered under their jurisdiction which applies to those vessels regardless of the location of their activities.

- Encourage the IMO to provide guidance and technical support to Parties to MARPOL for crafting effective domestic legislation for regulating the discharge of fishing gear from vessels at sea.

- Encourage regional and sub-regional fisheries organizations and arrangements to incorporate into their mandate and binding conservation measures a prohibition on discarding fishing gear and related fishing debris.

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IMPACTS OF MARINE DEBRIS:
RESEARCH AND MANAGEMENT NEEDS

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BACKGROUND

Although societies have altered natural environments since time immemorial, the magnitude, intensity, and rate of change have increased dramatically in the last seventy-five years. Nowhere is this more evident than in coastal areas, where growing populations, increased demands on natural resources, and powerful modern technologies have combined to bring about far-reaching changes in coastal and marine environments, not all of them favorable. Human-induced changes have been profound and continue to increase in scope, yet we have had neither the time nor resources to pause, study, and reflect on the remarkable impacts and how to mitigate them.

Marine debris is a good example of such change. Significant marine debris impacts can be traced to the 1940s when new synthetic materials began replacing natural fibers in the manufacture of fishing nets, line, and all sorts of everyday items. The low cost, light weight, and long life of new synthetic materials have resulted in more items being discarded, their transport to the most remote ocean shorelines and waters, and a much longer hazard life for marine species.

Although the roots of marine debris pollution date to the mid-1900s, its impacts on marine life were largely unrecognized until 1984 when the National Marine Fisheries Service (NMFS), at the recommendation of the Marine Mammal Commission, hosted the Workshop on the Fate and Impact of Marine Debris (Shomura and Yoshida, 1985). Data compiled at the workshop revealed that marine debris was affecting far more species in many more areas than previously realized. Its biological impacts were found to have two principal forms: (1) entanglement of animals in loops and openings of derelict line, nets, strapping bands, etc., and (2) ingestion of plastics causing damaged or blocked digestive tracks. Both are potentially lethal to marine life. In addition, human safety problems caused by fouling and disabling of vessel propulsion systems were noted.

The 1984 workshop spurred national and international efforts to investigate, monitor, and mitigate marine debris impacts (Laist et al., 1999). With regard to biological impacts, studies over the following decade documented entanglement and ingestion impacts in all the world's oceans. Interactions were reported in all but one of the world's sea turtle species, 74% (138 species) of all seabird species, 37% (28 species) of all cetacean species, 58% (19 species) of all pinniped species, and Florida manatees (Laist, 1996a). Many affected species were listed as endangered or threatened under national and international conservation programs. Entanglement was found to be more likely than ingestion to injure or kill marine life, and most entanglements involved fishing nets, monofilament fishing line,

rope, and strapping bands lost or discarded by commercial and recreational fisheries. Some seabirds and sea turtles, however, were especially prone to ingesting debris, such as plastic bags, cigarette lighters, light sticks, and small plastic fragments that were confused for floating prey. Potentially significant impacts to commercial fish stocks were also identified due to ghost-fishing (i.e., derelict fishing gear that continues to catch fish and shellfish for years after being lost or discarded [Laist, 1996b]).

Other studies focused on the types and amounts of debris in ocean areas (Pruter, 1987 and Ribic et al., 1997). They found that plastic items comprised the majority of marine debris, and that, in some areas, up to 90% of all debris was made of plastics. Still other studies focused on economic impacts, particularly those measured by diminished opportunities to use the marine environment for pleasure (see for example, Faris and Hart, 1995). Beaches, rivers, wetlands, and bays are used extensively by recreationists, and thus the consequences of aesthetic degradation, beach cleanups, and human health and safety impacts associated with marine debris may impose some of the highest economic impacts (Hoagland and Kite Powell, 1997; Holdnak, 1992; Smith et al., 1997). Over the years, countless news articles and anecdotes have been reported illustrating how marine debris, most notably sewage, medical items, and bottles and cans, threaten human health and safety and affect coastal communities.

Beginning in the mid-1980s, many notable actions were taken to address these problems. Among these were the following: (1) the U.S. Congress authorized funding for the Marine Entanglement Research Program in the National Marine Fisheries Service to improve understanding of marine debris problems and coordinate responsive federal actions, (2) in 1987, parties to the International Convention for the Regulation of Pollution from Ships 1973 and its 1978 protocol, (jointly known as MARPOL 73/78) took steps to implement Annex V, a convention annex for regulating the discharge of garbage from ships and prohibiting all at-sea discharges of plastics, (3) also in 1987 the U.S. Congress passed the Marine Plastics Pollution Research and Control Act (MPPRCA) to enact domestic authority for implementing Annex V, (4) the U.S. Navy implemented a program to develop and retrofit solid waste handling technology for all of its vessels, (5) a series of international meetings, workshops and symposia were held to review information on marine debris impacts and to identify priority research and management needs, and (6) the Center for Marine Conservation and other non-governmental groups organized a national beach cleanup campaign, that was expanded into an international program in 1990.

One region of the world that received intensive attention during the 1990s for its marine debris problems was the Caribbean. Twenty-two developing nations in that region received technical and financial support to implement the MARPOL 73/78 Convention and to help fulfill the requirements associated with the designation of the Wider Caribbean Region as a Special Area under Annex V of the Convention. The Special Area designation, adopted by the International Maritime Organization (IMO) in 1993, prohibits all at-sea discharges of vessel-generated garbage from ships, with the exception of ground food wastes that could be discharged beyond three miles from land (WCISW, 1997). Assistance for these nations became available in 1994 when the Wider Caribbean Initiative on Ship-Generated Waste Project (WCISW) was funded by the Global Environment Facility

through the World Bank and implemented by the IMO. Through the Project, half a dozen countries not already party to MARPOL 73/78 acceded to the Convention during the course of four years. Technical support was also provided to: (1) draft and implement marine pollution legislation in several countries, (2) develop regional and national strategies for handling vessel-generated wastes, (3) identify land-based waste management options (including reuse and recycling), and (4) increase and strategically place shore-based waste reception facilities.

SUMMARY OF RECOMMENDATIONS FROM PREVIOUS CONFERENCES, MEETINGS, AND REPORTS

As indicated above, several international meetings on marine debris were held during the 1980s and early-1990s to review and evaluate information on marine debris. Among these was a special session on marine debris at a 1986 ocean disposal symposium (Wolfe, 1987), a 1987 fishing industry conference on marine debris (Alverson and June, 1988), and two international conferences organized by the Marine Entanglement Research Program of the National Marine Fisheries Service in 1989 and 1994 (Shomura and Godfrey, 1990; Coe and Rogers, 1994) to follow up on the initial workshop convened in 1984. Participants at those meetings made recommendations on priority research needs, as well as steps to coordinate and guide mitigation work. Many of those recommendations remain unaddressed or only partly addressed.

With regard to assessing marine debris impacts, participants at the 1984 Workshop on the Fate and Impact of Marine Debris (Shomura and Yoshida, 1985) recommended steps to:

1. Assess marine debris impacts on living marine resources, including fish, northern fur seals, Hawaiian monk seals, seabirds, and marine turtles.

2. Determine impacts of ingestion of debris by seabirds and turtles.

3. Determine the severity of debris problems in areas other than the North Pacific Ocean.

4. Expand existing stranding networks for marine mammals, birds, and turtles to collect data on interactions with marine debris.

5. Obtain data on the amounts of gear lost by commercial fisheries, particularly high seas gillnet fisheries.

6. Determine the impact of marine debris on the sea floor.

7. Obtain worldwide data on vessel disablement as a result of interactions with marine debris.

In 1987 commercial fishing organizations sponsored the North Pacific Rim Fishermen's Conference on Marine Debris. The purpose of the conference was to identify research needs and industry outreach priorities from the fishing industry's perspective. Proceedings from the Conference (Alverson and June, 1988) urged that international

efforts be expanded to quantify population-level impacts of marine debris on marine species. It also recommended work to quantify economic impacts on commercial and recreational fisheries, and the development of fishing gear and fishing practices that would minimize ghost-fishing. Recognizing the long-term nature of work needed to address marine debris issues, conference participants also recommended that the National Oceanic and Atmospheric Administration provide long-term funding support to the National Marine Fisheries Service for its Marine Entanglement Research Program.

Also in 1987, President Reagan, at the request of thirty members of the U.S. Senate, directed the Office of Domestic Policy to establish an Interagency Task Force on Marine Debris to develop a coordinated strategy to address marine debris issues. Chaired by the National Oceanic and Atmospheric Administration, the task force completed its report in May 1988 (Office of Domestic Policy, 1988). The report called on all federal agencies to assess and mitigate marine debris impacts in cooperation with state and local governments, industry, academia, and private groups. It embraced advice developed at the earlier meetings, including recommendations for long-term support of the National Marine Fisheries Service's Marine Entanglement Research Program and for quantifying deleterious marine debris impacts on fish and wildlife and vessels. The task force report also recommended greater emphasis on: (1) documenting and resolving the aesthetic impacts of marine debris and its associated economic effects on coastal communities, and (2) determining and monitoring marine debris impacts on endangered, threatened, and depleted species. It also called for developing standards on the use of biodegradable plastics and for removing marine debris from beaches and other marine areas.

On 2–7 April 1989 and 8–13 May 1994, the National Oceanic and Atmospheric Administration convened the Second and Third International Conferences on Marine Debris in Honolulu, Hawai'i, and Miami, Florida respectively. Building on results of earlier meetings, participants at the 1989 conference recommended:

1. The preparation of a marine debris survey manual to standardize methodologies for monitoring marine debris on beaches.

2. Forming an international committee to coordinate collaborative efforts for collecting entanglement data and removing hazardous debris from habitats used by species, such as Hawaiian monk seals, sea turtles, and northern fur seals.

3. Studying potential lethal effects of plastic ingestion among sea turtles and seabirds, including studies to correlate ingestion of plastics and the occurrence of lesions in sea turtles, and to assess pseudo-satiation and possible toxic effects among seabirds.

4. Instituting measures to record and track the numbers of gillnets and traps lost during commercial fishing, to estimate ghost fishing rates in lost gear over time, and to develop mechanisms for reducing the length of time lost fishing gear could continue to catch fish and shellfish.

5. Evaluating economic impacts from vessel disablement, ghost fishing, cleaning debris off beaches, and reduced tourism.

The third international conference in 1994 made similar recommendations, but also noted needs to investigate the role of floating debris in transporting invasive, non-indigenous species to new marine areas and the potential for large-scale impacts from debris accumulations on the sea floor. They also reiterated the need to recover lost fishing gear in areas where it accumulates, to develop a system to record losses of commercial fishing gear, and to evaluate the types and amounts of fish and shellfish caught in lost gear.

In 1995, the National Research Council's Marine Board published the results of a comprehensive two-year study on actions needed to develop a national strategy for implementing MARPOL Annex V (National Research Council, 1995). Among other things, the report recommended that:

1. The National Oceanic and Atmospheric Administration, with help from the Environmental Protection Agency, establish a national program to monitor the flux of marine debris on beaches and benthos and marine debris impacts on wildlife.

2. The Environmental Protection Agency develop an overall framework for requiring and monitoring garbage discharges from ships and the availability of adequate port receptions facilities for ship-generated garbage.

3. The International Maritime Organization develop a garbage treatment technology program to develop new garbage handling technology.

4. Congress fund a foundation to coordinate a sustained, long-term program to educate and train the maritime sector in actions needed to properly handle and dispose of ship-generated garbage.

5. Congress establish a permanent national commission to provide consistent, independent oversight and coordination of actions to implement Annex V and the provisions of the Marine Plastic Pollution Control Act.

PROGRESS SINCE 1994

Since 1994 there has been a marked decline in efforts to address marine debris pollution. For example, despite progress made in the Wider Caribbean Region under the WCISW Project, funding for work ended abruptly in 1998 and the Wider Caribbean Special Area has not yet entered into force. Such designation will become effective only when countries and territories in the region notify the IMO that their ports, terminals, and marinas have adequate reception facilities. There is little likelihood of this taking place in the near term. There are many remaining organizational constraints, the necessary physical infrastructure in the form of reception facilities and solid waste management systems is, by and large, woefully inadequate, and operational aspects associated with national implementation and enforcement have not been formulated in many countries.

Attention to marine debris pollution in the United States also decreased sharply after 1994. In 1995 Congress eliminated funding for the Marine Entanglement Research Program as part of efforts to reduce deficit spending. In doing so, it effectively terminated the only

national-level program in the United States designed to coordinate and support federal activities to assess and mitigate marine debris pollution. Funded at between $600,000 and $750,000 per year, the program was the only source of federal funding available to investigate and mitigate the full range of marine debris impacts. In 1996 Congress amended the Marine Plastic Pollution Research and Control Act to direct that the National Oceanic and Atmospheric Administration convene a federal marine debris coordinating committee to oversee cooperative work by involved agencies to address marine debris pollution issues. However, no steps have been taken to convene such a committee. As a result, with three notable exceptions, most conference and report recommendations have received little or no attention over the past six years.

One area in which progress has continued is the development of a National Marine Debris Monitoring Program. In 1995 the Environmental Protection Agency, in cooperation with the Center for Marine Conservation, developed a national marine debris monitoring plan. Since 1996 the Agency has provided $100,000 per year to the Center to develop and implement a monthly sampling program to monitor derelict fishing gear and other marine debris at selected beaches around the nation. Although limited by funding, the program has established monitoring sites in several regions. Over time, the program will provide a means of assessing trends in the amounts of marine debris fouling the nation's shorelines. As a companion effort, with support principally from corporate sponsors, the Environmental Protection Agency, and the Coast Guard, the Center also has continued to coordinate international beach cleanups with volunteers annually removing trash from hundreds of beaches worldwide.

A ten-year study of beach trash along the 68-mile Padre Island National Seashore was completed in 1998 by researchers affiliated with the National Park Service and Texas A&M University-Corpus Christi. Padre Island, a barrier island located on the south coast of Texas, is annually visited by approximately one million people. The marine debris monitoring project, the most extensive of its type in the United States, used a variety of data collection methodologies, including quarterly beach transects and daily surveys over extended periods of time. During the decade, researchers collected nearly 400,000 trash items and concluded that most of the debris was from U.S. sources. The U.S. Gulf of Mexico shrimping fleet, and to a much lesser extent, the offshore oil and gas industry, were identified as the primary "point source" contributors to the problem (Miller and Jones, 1999).

The third area where efforts have been maintained concerns marine debris impacts on endangered Hawaiian monk seals and coral reefs in the Northwestern Hawaiian Islands. Since the early-1980s, the Honolulu Laboratory of the National Marine Fisheries Service has documented more than 200 monk seal entanglements, including a record high of 25 entangled seals in 1999. To address the problem, Service field crews routinely disentangled monk seals whenever necessary and possible, and removed hazardous debris from pupping beaches. To assess entanglement risks in surrounding waters, the Service conducted a dive survey for derelict fishing gear on reefs adjacent to pupping beaches in the winter of 1996–1997. Based on the results, it was estimated that there were 94 net fragments per square kilometer in waters less than 10 fathoms deep at French Frigate Shoals alone (Bowland, 1997). In response to the findings, the Service coordinated

cooperative reef cleanup efforts in 1998 and 1999 with other federal, state, and local agencies and private groups. Six tons of submerged net debris was removed from the reefs in 1998 and about 25 tons were removed in 1999. Most of the netting was from trawl nets that apparently had drifted into the area from distant fishing grounds. In addition to finding several monk seals entangled in net debris hung up on reef outcrops, the nets also were found to be damaging reef corals and other reef species. Because of the remote origin of the netting (there is no trawl fishing in the Hawaiian Islands), the State Department brought the problem to the attention of governments officials in key fishing nations around the North Pacific rim.

The few studies done to assess impacts on other species suggest that marine debris problems continue to exist. In one case, studies suggest that marine debris may provide a conduit for transferring toxic chemicals to marine life. Studies of plastic debris and plastic ingestion by albatrosses at Kure Atoll in the Northwestern Hawaiian Islands suggest that plastics, particularly cigarette lighters and light sticks, continue to be ingested frequently by albatrosses. Albatrosses in the Northwestern Hawaiian Islands also have high levels of PCB contamination. Recent studies suggest that this contamination may come from floating fish eggs and plastics that adsorb toxic chemicals as they bob through the surface micro-layer of the ocean, which may receive PCBs from contaminated land-based dust as it settles on the ocean. If such a transfer occurs, it could represent a significant, previously unrecognized concern for species that commonly ingest plastics and floating marine life. A recent study of plastic ingestion by sea turtles also concluded that post-hatchling sea turtles have an extremely limited ability to compensate for dietary dilution caused by debris in their digestive tracks and that they would experience sublethal effects from decreased energy and nitrogen intake (McCauley and Bjorndal, 1998).

A few studies have attempted to determine if ingestion and entanglement rates declined after MARPOL Annex V entered into force at the end of 1988. Shaver and Plotkin (1998) examined plastics in the digestive tracks of 473 sea turtles stranded along Texas between 1983 and 1995. They found ingested plastics in more than half of the turtles sampled, with no significant difference in the proportion of affected turtles before and after Annex V went into effect; ingested items were the primary cause of death for at least seven turtles. Arnould and Croxall (1995) examined entanglement rates of Antarctic fur seals at South Georgia Island in the Southern Ocean between 1988/1989 and 1993/1994. They found the incidence of entanglement declined by half after Annex V went into effect although the decline may have been related to a decline in fishing activity in the area. It was noted, however, that a decline in strapping band entanglements probably was related to education efforts urging fishers to cut strapping bands before discarding them. This conclusion was supported by a finding that all strapping bands found washed ashore on South Georgia during the 1993–1994 survey had been cut. Long-term efforts to monitor entangled northern fur seals on the Pribilof Islands also suggest a decrease in entanglement rates since MARPOL Annex V went into effect (Robson et al., 1999). Although funding decreases have reduced sampling efforts in recent years, work now is carried out largely by the local Native community during annual subsistence harvests. The results suggest that entanglement rates among juvenile male fur seals on haul-out beaches

declined from a high of about 0.7% in the mid-1970s to about 0.4% in the 1980s and about 0.2% between 1988 and 1997. As with Hawaiian monk seals, most net entanglements of northern fur seals have involved derelict trawl net.

Several studies to assess potential impacts from ghost fishing by derelict gear were undertaken prior to 1994 (Laist, 1996), some of which suggested significant impacts were possible. Since 1994, however, no further studies have been done to assess ghost-fishing rates or to estimate ghost-fishing impacts on commercially valuable fishery stocks. Other than the monk seal disentanglement work and related reef cleanup efforts in the Northwestern Hawaiian Islands, no efforts have been undertaken to mitigate entanglement impacts from derelict fishing gear.

UNRESOLVED ISSUES

Information on trends in the types and amounts of marine debris continues to be poorly understood. To detect statistically significant trends in the composition and quantities of marine debris, long-term monitoring studies, such as the U.S. National Marine Debris Monitoring Program supported by the Environmental Protection Agency and the National Park Service, need to be continued, refined, and expanded to cover new areas. Currently, monitoring programs comparable to the U.S. program do not exist in other countries. Such programs are needed to help determine which types and sources of marine debris require priority attention.

Other than ongoing studies to monitor entanglement of Hawaiian monk seals and northern fur seals on breeding beaches, little work is currently being done to monitor or assess impact of marine debris on living marine resources. The greatest unknown in this regard is the numbers of animals entangled and killed at sea that are never recorded by shore-based monitoring programs. One of the only instances where work has been undertaken to assess and mitigate entanglements away from shore is the above noted work in the Northwestern Hawaiian Islands to survey and remove debris in reef habitats adjacent to monk seal breeding beaches. Because of logistical challenges, the impacts of marine debris on living marine resources at sea remain poorly understood and documented. Currently there are no systematic studies to monitor long-term entanglement trends among pinniped populations other than Hawaiian monk seals and northern fur seals; nor are there systematic efforts to assess or monitor ingestion of marine debris by species, such as sea turtles or albatrosses, that frequently ingest large quantities of plastics. Although recommended at past marine debris meetings, no work has yet been done to correlate debris ingestion by sea turtles with the occurrence papilloma tumors in turtles.

Although several studies to assess and mitigate impacts of ghost-fishing were undertaken prior to 1994 (Laist, 1996), little appears to have been done since then. In some cases, ghost-fishing impacts may be significant. For instance, ghost-fishing losses for the sablefish trap fishery off British Columbia, Canada, have been estimated as high as 30% of actual landings (Faris and Hart, 1995). Carr et al. (1992) monitored ghost-fishing by two 100 m gillnets over a two-year period off New England and recorded a catch of 172 lobsters during just fourteen dive observations over that period. Considering the number of gillnets and other fishing gear lost in New England, such findings suggest that lost nets could catch

and kill a significant number of lobsters. The study also tested biodegradable float releases to minimize ghost fishing by reducing the net's vertical profile. Despite such work, no efforts have been made to gather data on the numbers or location of lost fishing gear, to estimate potential region-wide economic impacts, or to further develop potential mitigation measures.

Navigation hazards posed by marine debris, particularly for small craft, also remain poorly documented. Anecdotal reports of entangled motors, clogged water intakes, and propeller and hull damage are common. Despite several recommendations to compile data on such hazards, no systematic study of the economic costs of such damage has been conducted (Kirkley and McConnell, 1996).

A scan of the most recent literature on the benefits associated with a reduction of marine debris also indicates that the true social and economic costs remain unknown (Hoagland and Kite-Powell, 1997). For example, we do not have a complete picture of the magnitude of economic damages associated with the ecological effects of marine debris. No studies have been conducted to estimate the economic losses associated with the entanglement of marine mammals, turtles, birds and other aquatic wildlife and, as noted above, little has been done to estimate economic costs of ghost fishing. More in-depth investigations are also needed concerning costs to coastal tourism and recreation, as well as marine debris hazard costs to boat and ship owners. Investigations into economic costs to fisheries stemming from reduced public appeal for the products due to pollution from trash and inadequately treated sewage also have not been done.

OPPORTUNITIES FOR IMPROVEMENT AND ACTIONS NEEDED

To mitigate marine debris pollution, it is essential to document and monitor its occurrence. The National Marine Debris Monitoring Program supported by the Environmental Protection Agency and carried out by the Center for Marine Conservation has been designed to address this need on a national level. Its continuation as a long-term funding priority should be a fundamental component of any effort to resolve marine debris issues. Further work is needed to establish monitoring sites in all regions of the country, and conference participants should consider work done to date to develop this program as an opportunity to gather baseline data on regional marine debris problems and trends. In some cases additional surveys may be needed to identify particular problem areas, such as has been done in the Northwestern Hawaiian Islands.

There also is a need for further work to assess and monitor biological impacts of marine debris. Ongoing monitoring of entanglement rates for Hawaiian monk seal and northern fur seal populations should be continued, and opportunities may exist to develop similar programs for species in other areas. Further work also is needed to assess and monitor ingestion of plastics by species, such as sea turtles and albatrosses, that frequently ingest large quantities of marine debris. Recent improvements in regional marine mammal and sea turtle stranding programs and fishery observer programs provide an opportunity to collect data on ingestion of plastics, and consideration should be given to supporting routine collection and analyses of stomach samples from these sources. As a related matter, studies may be needed to determine whether floating plastics adsorb toxic chemicals that could be transferred to marine life via ingestion.

The impacts of ghost-fishing by derelict fishing nets and traps merit particular attention. In most cases, past recommendations to address its effects have received little or no funding. Studies of submerged fishing debris in the Northwestern Hawaiian Islands illustrate the type of problems that may exist and similar work should be considered for other locations where derelict fishing gear may accumulate (e.g., major fishing grounds or coastal waters where floating debris can be deposited). In addition to determining densities of lost gear in particular areas, such studies could be designed to assess: (1) the types and quantities of marine life, particularly commercially valuable crab and lobsters, caught in submerged derelict gear, and (2) the feasibility of dedicated cleanup efforts to remove lost gear from sea floor areas where it is most concentrated. Further work on gear modifications that would render lost gear less harmful to marine life also would appear to merit consideration. Long-term studies similar to Carr et al. (1992) to monitor interactions between marine life and derelict gear also should be considered. Their purposes could be twofold: (1) documenting the catch rates by different types of derelict gear in different areas over multi-year periods, and (2) testing gear modifications that could make lost gear less hazardous to marine life (e.g., the use biodegradable materials). Fishing industry grants made available by the National Marine Fisheries Service provide an opportunity to support such work; however, to date, grant applications in this area have received low priority and gone unsupported. Establishing a higher priority for work to resolve derelict gear issues in fishing industry grants could help address funding limitations.

Other actions that may merit consideration relative to ghost fishing include requirements for reporting when and where gear is lost, and the institution of fishing gear deposit systems to create an economic incentive for recovering and properly disposing of old or derelict fishing gear at land-based disposal sites. Because many land-based disposal sites discourage, or even prevent, disposal of fishing gear in landfills, steps may be needed to identify or arrange for disposal sites for fishing gear.

Although some studies have been conducted on the public's willingness to pay for the control of marine debris and a clean marine environment, more research in this field should be considered. A survey of users and nonusers of beaches and estuarine reserves in North Carolina and New Jersey concluded that individuals were willing to pay twice as much to clean up a beach than they were to clean up an estuary (Zhang, 1995). Also, incentive systems consisting of bounties, taxes, deposits, rebates, etc., may merit investigating in some locales. Hoagland and Kite-Powell (1997) recently concluded that the Gulf of Maine had seen modest reductions in bottle debris over time, and that this coincided with the adoption of bottle deposit and refund legislation. As noted above, incentive-based solutions may be particularly helpful for marine debris problems in fisheries and fishing communities. A Canadian study found that commercial fishermen, if adequately informed, are more likely to return garbage to port when waste collection facilities are readily available (Topping, 1997). Others have concluded that tax/subsidy systems are economically viable, but that they should be limited to selected items in the waste stream (Dinan, 1993; Palmer and Walls, 1994; Fullerton and Kinnaman, 1993). One such item might be fishing gear, particularly the netting, traps, and cordage that have been traditionally discarded or lost at sea.

To help address all of these issues, consideration also should be given to funding and coordination needs. For example, based on conference results, consideration should be given to recommending that: (1) Congress reinstate funding for a national marine debris research and management program similar to the former Marine Entanglement Research Program to help fund the broad range of projects needed to assess and mitigate marine debris impacts, and (2) the National Oceanic and Atmospheric Administration convene a national marine debris coordinating committee pursuant to directives of the Marine Plastic Pollution Research and Control Act.

TOPICS FOR FURTHER DISCUSSION

Based on information presented at the conference, participants should consider recommended actions in the following areas.

1. Monitoring studies to determine the types, amounts, and accumulation trends of derelict fishing gear and other forms of marine debris:
- Continued support for the National Marine Debris Monitoring Program.
- Additional studies to identify and document regional areas where marine debris accumulations may occur.

2. Assessing, monitoring, and mitigating impacts of derelict fishing gear and other marine debris on living marine resources:
- Continuation of shore-based studies to document and disentangle Hawaiian monk seals and northern fur seals.
- Studies to document other entangled marine species.
- Collection and analyses of ingestion data on albatrosses, sea turtles, and other species.
- Assessment of the adsorption of toxic chemicals by marine debris likely to be ingested by marine species.

3. Assessing and mitigating ghost-fishing impacts:
- Conduct underwater surveys to document densities of derelict net debris and traps in major fishing areas or areas where drifting debris may concentrate, and to test feasibility of dedicated cleanup work.
- Conduct multi-year studies of species and catch rates in different types of derelict fishing gear in different areas.
- Collect or require reporting of data on the when and where fishing gear is lost during commercial fishing operations.
- Study potential gear modification that would reduce the probability of fishing gear being lost, increase the probability of lost fishing gear being found, and reduce the hazard life of lost gear not recovered.

4. Considering economic incentive-based solutions for marine debris problems. A range of policy approaches should be investigated, including those that:
- Establish deposits, refunds, or bounties for gillnets, fish traps, light sticks, and other items frequently or occasionally lost during commercial fishing.
- Ensure convenient and affordable solid waste management systems are available to accept commercial fishing wastes, including old fishing gear.

- Consider that economically inefficient fishing effort has accompanied open access to most species. We need to investigate whether taxation designed to limit effort, and thus reduce the likelihood of gear losses, overboard disposal, etc., would result in societal benefits.
- Investigate higher taxation possibilities for items that cannot be recycled and subsidies for those that can be recycled.
- Determine whether penalty mechanisms, such as fines, are effective at controlling the problem or if there are better and more cost-effective options.

5. Continuing to support studies designed to assess the economic and social costs of marine debris to coastal tourism and recreation and navigation interests. This information can be used to continue educating policy-makers and stakeholders.

6. Establishing a framework to support and coordinate marine debris impact ssessment and mitigation activities:
- Request that the National Oceanic and Atmospheric Administration or some other agency establish and secure funding for a national marine debris research and monitoring program similar to the former Marine Entanglement Research Program.
- Request that the National Oceanic and Atmospheric Administration convene a national marine debris coordinating committee pursuant to provisions of the Marine Plastic Pollution Research and Control Act.

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SOURCE IDENTIFICATION OF DERELICT FISHING GEAR: ISSUES AND CONCERNS

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BACKGROUND

No fewer than four international conferences have convened to address the problem of marine debris and derelict fishing gear (Shomura and Yoshida, 1985; Alverson and June, 1988; Shomura and Godfrey, 1990; Faris and Hart, 1995). Each of these conferences has addressed identifying the land or maritime sources of debris, including the fisheries that generate derelict gear such as nets, net fragments, and traps. The impetus for source identification has been primarily to provide direction for activities designed to prevent continued accidental loss or intentional discard of such gear. These activities include improved port disposal facilities, public awareness campaigns, and gear modifications. With the ratification of Annex V of MARPOL 73/78, which prohibits the discharge of plastics from ships of nations party to the Annex, source identification gained added importance as a law enforcement tool, although any citation or enforcement action would require identification ascribed to a particular vessel.

Derelict fishing gear can be identified with increasing degrees of precision, from fishery, to manufacturer, to individual user. Source identification to a particular fishery requires a broad knowledge of fishing equipment and methods. This expertise no doubt exists collectively among fishermen, gear manufacturers and specialists, and biologists, and some compendia have been assembled (Uchida, 1985). However, summary publications quickly become outdated as technology and fishing methods change, and current information may not be published or readily accessible. Identification of a manufacturer requires unique elements which are introduced during construction of the particular webbing, net, or other gear implement. These may be intentional tracers introduced to function as a de facto trademark, or may be particular aspects of construction which result from the manufacturer's (patented) design or fabrication. Identification to individual user requires insertion or application of unique identifiers after the gear has been purchased from the manufacturer or supplier. These procedures are used in trap fisheries in which return of lost equipment is desired, including tagged crab or lobster traps, or color coded buoys. Set net fisheries may also have individual markings on buoys, although the webbing is not marked. Trawl or drag fisheries seldom have individual markings.

PREVIOUS RECOMMENDATIONS

Each of the previous conferences has provided a suite of recommendations related to the detection, management, and mitigation of marine debris. Some of these recommendations have related to the identification of debris sources, and are listed below.

1984 Recommendations

Recommendations from Marine Debris working group:

1. Fishermen groups and net manufacturers should be asked to assist in identifying specific types of nets and net components which are most involved in entanglement.

2. Requirement for identification of fishing nets to identify source and areas lost.

3. Confirm sources of marine debris and expand studies of their distribution in the marine environment.

Recommendation from Impacts working group:

1. Require Net Identification.

2. Develop a reference collection of debris, particularly nets.

Recommendations from Management Needs working group:

1. A reference catalogue of netting materials be developed.

2. Economical and effective systems be developed to mark gear through color coding or other means for retrieval and identification of source.

1988 Recommendation

1. Examination of cost-effective systems to facilitate the identification, recovery, and return of lost fishing gear to port or owners.

1990 Recommendation

Recommendation from working group on Entanglement of Marine Life:

1. The preparation of a guide to the types of lost or discarded nets.

1994 Recommendation

1. Where possible, sources of marine debris should be identified by countries of origin and user groups using item codes and shapes from industry, epiphytic organisms (that travel on ocean borne debris) and cargo manifests.

ACTIONS SINCE PREVIOUS CONFERENCES

Reference Collection

Commencing in fiscal year (FY) 1985, the U.S. Congress provided funds to the National Marine Fisheries Service (NMFS) for a comprehensive research and management program to address the problem of marine debris. The resulting Marine Entanglement Research Program (MERP) coordinated mitigation, education, and research activities for ten years,

until its funding was discontinued in FY 1996 (Marine Mammal Commission, 1997). MERP supported a wide suite of projects, but little support was garnered for identifying debris sources. A project was funded ($48 K) for one year, FY 1985, to establish a reference collection for nets, but by the following year this project was discontinued in lieu of funding for other, higher priority activities. The one-year effort resulted in an incipient reference collection at the Alaska Fisheries Science Center (AFSC) in Seattle, Washington, with notification that the AFSC would accept samples for identification (Herkelrath et al., 1991). Parts of the original reference collection remain at the AFSC (Jim Coe, AFSC, pers. commun.). No reports resulted from the project.

Since 1986 no formal effort has been undertaken to establish a reference collection of nets or other fishing gear. The original reference collection has not expanded, and has seldom been used (Dave King, AFSC, pers. commun.) One of the authors (JRH) used a collection of net samples collected by U.S. fisheries observers in the early-1980s to assist identification of debris collected from the Northwestern Hawaiian Islands in 1998. However, this ad hoc collection resulted in tentative identification of only 36% of the webbing samples collected, and only 14% with a high degree of certainty (NMFS Unpubl. data). The collection was obviously not complete, and may have been outdated.

Individual Gear Markers

Unique marking of fishing gear has progressed little beyond painting or tagging of buoys and floats to which traps or set nets are attached. These methods do not identify scraps of webbing or other gear fragments which become detached from the buoys. Identification of fragments requires small, unobtrusive markers which do not affect the performance or durability of the gear. One such marker is a coded wire tag (CWT) developed for biological applications (Jefferts et al., 1963). CWTs are used in fisheries worldwide, and have been suggested as suitable for use to tag gear (Jefferts, 1988). Tags would be implanted in line or webbing at intervals close enough to provide identification of even small scraps of debris.

It may be technically possible to more closely identify the source of derelict gear fragments, particularly if the full capability of forensic science is applied. Potentially useful forensic methodologies exist that could be brought into the identification of gear fragments.

Although the technology exists to identify derelict gear down to the user level, application of the technology requires careful consideration of many factors. Extra expense would accrue to any manufacturers providing gear containing the individual tags, which would likely result in higher costs to the consumer. A database of registered gear owners would need to be established and maintained, on either a national or a multinational scale.

Oceanic Regime, Drift Patterns

Knowledge of oceanic drift patterns is generally most useful in determining where pelagic flotsam is likely to accumulate. Kubota (1994) simulated the effects of Stokes drift, Ekman drift, and geostrophic currents on theoretical debris items placed throughout the North Pacific. The resulting movement predicted all debris becoming situated in a narrow band running approximately ENE-WSW, crossing the Northwestern Hawaiian Islands (NWHI) in the vicinity of Laysan and Lisianski Islands. Theoretical debris items placed

across the North Pacific Ocean at 45 N were predicted to concentrate, forming an area of high debris density at 27 N, 170 W, approximately 220 km NE of Laysan Island. Matsumura and Nasu (1996), summarizing six years of surveys documenting drifting debris, confirmed that the Pacific region north and northeast of Hawai'i showed relatively high densities of fishing gear and nets.

Ongoing analyses (Brainard and Foley, unpubl. data) have used scatterometer winds to compute oceanic convergence/divergence, a useful means to examine accumulation of debris by wind driven currents. These analyses reveal seasonal and interannual variability in the NWHI. Additional analyses will improve the ability to predict the fate of derelict gear.

Knowledge about drift patterns provides little information on the sources of derelict fishing gear. Variability in oceanic currents and wind drift prevents accurate "back calculation"of the site where debris would have been introduced. Moreover, the length of time which an item has been adrift is never precisely known; any derelict gear could have circulated in a gyre for long periods of time, having been lost or discarded in any area contacted by the circulating water mass.

POLITICAL CONSIDERATIONS

Previous discussions between government regulators and fishing industry representatives (Anonymous, 1988) have revealed very serious concerns among fishermen regarding individual gear markers, such as CWT marking. Fishermen have expressed concerns about the potential legal liability of having their gear individually marked for debris fragment identification. Beyond the information collection infrastructure necessary, the political repercussions of gear tagging need to be carefully considered.

Dissatisfaction with a proposed regulation should not be grounds to abandon its consideration. Many regulations currently in place to protect the marine environment are not particularly popular, but are nonetheless effective and deemed necessary to protect the public interest. However, it is not currently evident that the potential benefits of gear marking would be worth the costs. If derelict gear is found at French Frigate Shoals, Hawai'i that had been sold to the "F/V Sloppy Seas" in Alaska, what exactly does that mean for regulators and educators? Moreover, do better ways than gear marking exist to reduce discards or lost gear from this and other vessels?

UNRESOLVED ISSUES

If source identification is to be practical, it must contribute substantially to reducing debris at its source. A central issue is to determine how source identification might contribute to debris reduction. Ignorance of how source identification could help mitigate the derelict gear problem may have contributed to the historic lack of attention by government regulators to the issue of source identification.

The overall intent of source identification is to detect spatial and temporal patterns or trends in derelict fishing gear entering the marine environment. Derelict fishing gear in the marine environment has two very distinct origins—intentional and illegal discards, and unintentional loss. The mitigation options for each scenario are distinctly different. If a sig-

nificant percentage of problem debris (such as derelict gear that is responsible for entangling sensitive marine organisms) were identified to a particular fishery, more investigation and mitigation could be directed toward that fishery. These could include such efforts as learning whether these gear fragments are intentionally discarded or accidentally lost, increased outreach/education activities, fishery management solutions, or fishery-specific incentives.

For example, if a significant amount of net and line fragments that are entanglement threats can be identified to, say, a Taiwanese shrimp trawl fishery in the South China Sea, then various mitigation options are available. If the fragments appear to have been intentionally discarded, as evidenced by trimmed edges characteristic of webbing patches removed for repair, then mitigation options for that fishery could include increased observation by onboard fishery observers, port/vessel inventory systems, gear marking, rewards for reporting violations, punitive fines for violations, market-based/consumer pressure, and education of deck hands and skippers regarding the deleterious effects of intentionally discarded fishing gear. If, on the other hand, the gear fragments appear to have been accidentally lost, evidenced by large, obviously stretched, frayed, chafed, and torn components, then other management solutions might be considered. Areas of known trawl hang-ups or rough bottom that contribute to a large amount of torn and lost gear could be closed to trawling, gear modifications might be instituted, or Individual Fishing Quotas (IFQs) might be implemented. IFQs assign fishing rights to individual vessels/owners, thereby allowing the fleet to fish in a more leisurely, safer manner and on less difficult bottom terrain. In serious cases, managers might consider closing fisheries entirely to specific problem gear types (as occurred in the high-seas driftnet fishery).

Mitigation options should be targeted as specifically as possible for three principal reasons: (1) to have maximum effectiveness, (2) to make the best use of limited financial resources, and (3) to avoid unfairly burdening other nonproblem fisheries. If derelict gear can be identified to a particular fishery, then mitigation options need not be applied unnecessarily to other fisheries.

POINTS FOR WORKING GROUP DISCUSSION

- What is the feasibility of developing a gear reference collection?
- How would a reference collection be used? By what groups? For what purposes?
- How would a reference collection be developed? Where would it be maintained?
- How could a reference collection be kept current?
- What is the feasibility of individually tagging gear?
- What are the benefits or disadvantages of gear tagging?
- How would the infrastructure be developed to establish a gear registry?
- What agency or agencies would maintain the registry?
- What would be some uses of a registry? MARPOL enforcement? education?
- What are the political ramifications of individually tagging gear?

SOURCE IDENTIFICATION OF DERELICT FISHING GEAR:
ISSUES AND CONCERNS

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INDUSTRY CONSIDERATIONS AND ACTION

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1.0. INTRODUCTION

More than 170,000 people work as commercial fishermen in the United States. In 1998, U.S. commercial fishermen landed about 9.2 billion pounds (4.2 million metric tons) of fish and shellfish at U.S. ports, valued at approximately $3.1 billion. An additional 400.8 million pounds (181,800 metric tons) were landed outside the United States. Purse seine nets and trawl nets accounted for more than 70% of the total catch. Among the other fishing gear used were longlines, gillnets, set nets, trolling gear, and pots. American consumers spend almost $50 billion each year for fish and shellfish products. Thousands of businesses located throughout the United States, produce, process, and distribute seafood products. These firms contribute more than $25 billion to the U.S. Gross National Product (National Fisheries Institute, 2000).

There are an estimated 15 to 17 million recreational fishermen in the U.S. In many fisheries, recreational fishermen harvest as many or more fish than commercial fishermen (e.g., bluefish, red drum, striped bass, summer and winter flounder, Spanish mackerel, spot, spotted seatrout). In 1994, recreational landings of finfish, from Maine to Texas and Oregon to California were over 173 million fish weighing almost 200 million pounds. In 1997, nearly 17 million recreational fishermen made 68 million marine fishing trips to the Atlantic, Gulf, and Pacific coasts. The estimated marine recreational finfish catch was 366 million fish or roughly 423 million pounds (NMFS, 2000). It has estimated that the recreational boating and fishing industries may put as much as $60 billion annually into the U.S. economy (Recreational Fishing Alliance, 2000).

While plastics were first developed in the 1860s, they did not begin to replace natural fibers in fishing gear construction until the 1940s. Shortages of materials such as rubber during World War II led to the rapid development of plastics. By 1964, the majority of nets manufactured in Japan, one of the major suppliers of nets to American fisheries, were constructed of plastics (Uchida, 1984).

Synthetic fibers have led to significant technological advancements in fishing gear design and construction. Modern fishing gear, constructed of synthetic fibers is cheaper, more durable, lighter, stronger, and more efficient than most traditional gear. While synthetic fibers have led to immeasurable benefits to society, there have been associated costs.

Because they are resistant to degradation, synthetic fibers persist longer than natural fibers in the marine environment. Once lost in the ocean they have the potential to continue to fish and adversely affect the environment. Known impacts of lost and discarded fishing gear include the entanglement of marine life (i.e., fish, mammals, sea turtles, and seabirds), navigational hazards to vessels, and habitat impacts. Because they are relatively inexpensive, synthetic fishing nets may provide an economic incentive to fishermen to discard damaged or worn nets and line instead of investing the time and energy to repair them.

An estimated 80% of the marine debris found in the ocean originates from land-based sources (Faris and Hart, 1995) and 20% originates from maritime sources. Plastic production pellets, transported by merchant ships to manufacturing sites where the are melted down and made into various plastic consumer goods are found throughout the world's oceans.

Commercial fishing gear accounts for approximately 5% of the total debris found in the ocean (O'Hara et al., 1988). Other maritime sources of marine debris include merchant ships, recreational boats, cruise ships, military vessels, and offshore oil rigs. Research has shown that the type and source of plastics vary by geographic location. While in most instances the predominant plastic debris was packaging (bottles, bags, and lids), in Alaska it was fishing gear, such as webbing, rope, and floats (Faris and Hart, 1995).

Because lost and discarded fishing gear has a great potential to impact marine life and habitat, its reduction is a high priority. Prevention is the key to the solution of this problem. Participation and input by the fishing industry is critical to developing reasonable solutions. The fishing industry has participated in a number of previous marine debris and derelict fishing gear conferences and will participate in this fourth international conference.

2.0. BACKGROUND INFORMATION

A. Fisheries Operating in the Pacific

The Pacific Ocean contains some of the world's most productive fisheries. A number of small and large scale fisheries operating around the margins of the Pacific employ a variety of gears and methods to target a wide range of species. Principal gears include bottom and mid water trawls, gillnets, pelagic longline, demersal longline, troll gear, hook and line, traps, and purse seines. The trawl fisheries of the northeastern and northwestern Pacific are among the largest fisheries in the world and take large volumes of gadoids (pollock and cod), sebastes (rockfish), and various flatfish.

High seas fisheries in the Pacific target schooling pelagic species, such as tunas and squids. Tunas are taken predominantly by purse seine vessels which target skipjack and juvenile yellowfin tuna and other small tunas for the canning industry. Larger, adult albacore, bluefin, yellowfin, and bigeye tunas are the principal targets of longliners, which in some cases also target swordfish. Other open ocean pelagic fisheries include albacore trollers and pole-and-line vessels fishing for skipjack. Squid are caught on the open ocean using light attraction at night and squid-jigs.

Major trawl fisheries, both domestic and international, occur in the North Pacific. Generally trawl fisheries may be classified as either bottom or mid-water trawl. Bottom trawls are cone-shaped nets that are towed on the bottom. Two cables are used to tow the net and retrieve it. Large rectangular doors attached to the cables keep the net open while deployed. Large circular rollers, called "rock-hoppers" attached to the nets foot rope are used to fish on hard, rocky bottoms.

Mid-water trawls also employ cylindrical shaped nets. Mid-water trawls are generally towed at various depths above the bottom. Table 1 summarizes the U.S. domestic fleet operating in the Gulf of Alaska and Bering Sea.

Table 1. **Fleet sizes of U.S. Vessels operating in the Gulf of Alaska and Bering Sea (1998)**

Vessel Type	Gear Type	Vessel Size	Fleet Size
Trawl catcher processor	Trawl	>125 feet	51
Trawl catcher	Trawl	50-150 feet	230
Longline catcher processor	Demersal longline	>100	43
Longline vessels	Demersal longline	-	2,000
Pot catcher processor	Traps	-	7
Pot vessels	Traps	-	800
Set net vessels (salmon)	Gillnet	-	4,000
Seine vessels	Seine	-	1,000

Source: NPFMC, 2000

Gillnets are widely used throughout the North Pacific including Canada, Japan, Russia, and the United States. Uchida (1984) provides a thorough review of existing fisheries. Gillnets are constructed of monofilament line and typically have a float lead lines. Typically a number of nets, or "panels" are joined together. Gillnets may be anchored to the bottom of the sea with the use of weights or allowed to drift. Fish are captured as they attempt to swim through the net.

In the early-1980s many of the Asian distant water fleets including Japan, Korea, and Taiwan begin to use large-scale drift gillnets in the North Pacific to catch salmon, tuna, and squid. Vessels involved in the fishery typically would set up to 40 miles of net per night. The United States and Canada expressed concerns about the amount of salmon being intercepted on the high seas by this fishery, thus depriving domestic fisheries the opportunity to harvest these fish. In addition, large numbers of other marine life were inadvertently captured and kill by the fishery including marine mammals, sea birds, and sea turtles. In 1991, the United Nations General Assembly, in response to mounting international pressure, adopted a Driftnet Resolution calling for a global moratorium on large-scale high-seas driftnet fishing effective December 31, 1992.

Major longline fisheries exist in the Pacific. Table 2 summarizes existing pelagic longline fleet sizes currently operating in the Central Pacific. The U.S. domestic longline for swordfish in the North Pacific is a relatively new fishery. The introduction of chemical light sticks in the late-1970s revolutionized the industry. Lights are attached by rubber bands or line clips to the branch lines above the hook. The light sticks produce a chemical luminescence for up to twenty-four hours. The lights are available in a variety of colors and are thought to attract either the bait upon which swordfish prey, or the swordfish themselves.

Table 2. **Fleet Sizes of Pelagic Longlines, Operating in the Central Pacific (1997-1998)**

Nation	Fleet Size
China	110
Japan	1,573
Korea	148
Taiwan	1,674
United States	125

Source: WPFMC

Major trap fisheries exist in the North Pacific for king, tanner, and dungeness crab. The traps used in these fisheries are typically large (8" x 8" x 3") constructed of iron rods covered with some type of netting. Large numbers of traps are set in the crab fishery. Traps are typically set individually with one to multiple buoys to mark their location. Traps are also used to target some species of fish such as cod.

The use of free floating, fish aggregation devices (FADs) by purse seiners operating in the eastern, central, and western Pacific is another source of derelict fishing gear. Purse seine vessels set either on free swimming schools of tuna on the surface of the ocean during the daylight hours or on schools found associated with drifting logs or man-made rafts. Just before dawn. The increasing use of drifting fish aggregation devices (FADs) is a relatively recent development in the fishery. In the Central Western Pacific, the U.S. fleet made 90% of sets on untethered FADs in 1999 up from about 30% in the previous year (Coan et al., 1999). These FADs are roughly 2 m x 2 m rafts with a radio beacon for tracking and recovery. Netting, often worn out purse seine nets, are suspended beneath the FADs to create habitat and attract fish.

Recreational fisheries are another source of lost fishing gear present in the ocean. Recreational fishing is a highly popular pastime throughout the Pacific. In Hawai'i, large amounts of light gauge, monofilament line lost by recreational fishermen is found on beaches and coral reefs. Monofilament fishing line presents an entanglement threat to various marine life including sea turtles. The line may get wrapped around the turtles flipper and restrict its movements and ultimately may sever the appendage. In Hawai'i in recent years the rate of stranded turtles having some sort of recreational fishing equipment around them has increased from about 5% to about 15% (Laurs, 2000). In 1999, 43 of the 299, or 15%, of documented turtle stranding the turtles had recreational fishing hooks in them. Twenty of the 43 turtles strandings related to recreational fishing were dead when recovered. The remaining 23 turtles were entangled in monofilament line (Laurs, 2000).

B. Causes of Gear Loss

Fishing gear is lost at sea through a number of ways. It can be lost inadvertently during the course of normal operations or, in some cases, through deliberate disposal. The following section briefly describes some of these pathways.

Bottom trawls may become snared on underwater hang-ups including rocky bottoms and the wrecks of sunken vessels. When fishing in areas of high relief bottom, nets must be constantly inspected and repaired as they are damaged in the course of normal fishing operations. When nets hauled back with tears and rips they must be mended either by sewing in new meshes or, when large sections have been badly damaged, entire new sections of net. As part of the mending process small sections of mesh are often cut out before sewing in the new webbing. Some of these damaged sections may be discarded, either unintentionally or intentionally.

Bottom trawls are occasionally lost entirely due to hang-ups on bottom features, such as ledges, pinnacles, rock piles, and wrecks. Because of the substantial cost of replacing a net (~$30,000) vessels go to great lengths to recover a lost net. One method used is towing a

grappling hook over the spot where the net was lost until the net is recovered. Because of the potential damage to gear and the subsequent loss of fishing time, vessels typically mark the location of hang-ups and wrecks on their charts and plotters. Nets lost in this fashion likely remain entangled on the bottom.

While mid-water trawls are designed to fish up in the water column they can be fished at or near the bottom and therefore may potentially be damaged due to hangups, particularly in rocky or high relief areas.

Gillnets may be lost as a result of a number of factors, including net repair, interactions with mobile gear, entanglement on bottom features such as ledges, wrecks, and storm events.

While the use of high seas driftnet gills has been banned since the early-1990s, illegal vessels are still reportedly using driftnets to poach fish within the U.S. Exclusive Economic Zone (EEZ) as well as on the high seas. Numerous documented cases exist of illegal driftnet vessels simply abandoning gear in the water once detected by surveillance aircraft in an effort to elude apprehension. The abandonment of illegal gear is another source of fishing gear entering the marine environment. Given the large amount of gear deployed, undoubtedly some was lost in the course of normal fishing operations. Due to the persistent nature of synthetic monofilament gillnets and the long residency time of gear once lost in the marine environment, there is likely large amounts of driftnet still circulating within ocean currents and large scale eddies.

In longline fishing, as the mainline is retrieved, the crew generally removes branch lines, buoy lines, lights, and radio buoys, which are readied for the next day's set. Throughout the haul damaged sections of the mainline are replaced. The damaged sections may be unintentionally or intentionally disposed of into the ocean. Light sticks are also lost during the course of normal fishing operations. The light sticks are positively buoyant and of a shape and size that, if inadvertently lost from the branch line or discarded improperly, can create problems if ingested by marine mammals, seabirds, or marine turtles. Naval and merchant marine shipping also reportedly use large quantities of light sticks.

Traps are lost through a variety of ways. In heavy seas it is not always possible to locate all the buoys marking the lobster pots. Major storm events can also lead to the displacement and loss of crab traps. Tides may run so strongly in areas that the buoys marking lobster and fish traps are submerged. Thus, vessels may not be able to locate and retrieve all the gear it set.

Vessels often operate at or near the edge of the ice front and may lose traps as the ice edge advances. The buoy marker lines may be severed by ice. Interactions with mobile gear such as trawls may result in traps being displaced and lost. It is estimated that trap loss in the North Pacific king crab and tanner crab range from 10% to 25% (Kruse and Kimker, 1993; High and Worlund, 1979 in Carr and Harris, 1997). In Alaska, current regulations require that the trap escape panel be constructed of some type of biodegradable material to reduce the potential for lost traps to continue to fish.

As previously noted, interaction between different fisheries and gear types are another potential means by which fishing gear may be lost. In the case of areas where both fixed gear (i.e., trap and gillnets) and mobile gear (trawl) fisheries operate simultaneously, gear interactions result in the displacement and loss of fishing gear. Mobile fishing gear may displace lobster traps and damage gillnets. Fixed gear such as gillnets and traps may be displaced, damaged, or destroyed by vessel traffic. Longlines may also be parted and sections lost if cut by the propeller of transiting freighters or vessels.

Purse seine vessels reportedly set large number of FADs, some of which are lost. Once lost FADs could be a marine debris issue if washed up on beaches or coral reefs. Purse seine nets are rarely lost during normal use.

Under extreme circumstances, vessel emergencies and matters of safety at sea may contribute to the discarding of fishing gear by vessels. Fixed gear fisheries such as the North Pacific crab fishery operates under some of the most inclement weather conditions found anywhere on earth. In heavy seas and arctic conditions stacked crab pots may begin to "ice up" due to spray and sub-freezing temperatures. As ice accumulates on the stacked pots the vessel can rapidly become unstable due to the excess weight and ultimately, unless the situation is remedied, sink with a loss of part or all the crew. Under such conditions crews most often "break ice," removing ice from railing, decks, superstructure, and stacked gear. Under extreme conditions it may be necessary to jettison stacked traps to ensure the vessels stability and safety.

Non-compliance with existing domestic and international laws is another source of derelict fishing gear present in the ocean. As is the case under any regulatory regime, there is a some non-compliance. Despite MARPOL, fishing gear continues to be deliberately discarded by some unscrupulous vessels and crew. Enforcement alone will not achieve compliance with MARPOL Annex V. Industry education and outreach programs, such as U.S. Coast Guard's SeaPartners campaign are an important part of the solution.

C. Past Efforts

The International Convention for the Prevention of Pollution from ships at sea (MARPOL) was drafted and signed in 1973. MARPOL established specific guidelines governing the discharge of wastes by vessels at sea. It was amended in 1978 to include five annexes on ocean dumping. Annex V deals specifically with the disposal of plastics, including synthetic fishing nets by vessels. The Marine Plastic Pollution Research and Control Act (MPPRCA) of 1987 is the U.S. domestic legislation that implements MARPOL Annex V in U.S. waters.

Under the MPPRCA, any vessel greater than 26 feet in length are required to prominently post a 4" x 6" MARPOL placard that explains the garbage dumping restrictions. Vessels 40 feet and larger are required to develop a written waste management plan that describes how the procedures used by the vessel for handling the vessel's garbage in accordance with MARPOL Annex V laws. The plan also must name the crewmember in charge of carrying out the plan. In addition, vessels are required to maintain a detailed waste logbook that details the handling and disposal of plastics and other wastes. These records

are to be maintained onboard the vessel for at least two years and are to be available to the USCG for inspection upon request.

Under MARPOL and the MPPRCA, it is illegal for any U.S. vessel to discharge plastics in any navigable waters within the EEZ or on the high seas. Violations can result in fines of up to $50,000 for each incident. If criminal intent is proven, an individual may be fined up to $250,000 and/or imprisoned up to five years. If an organization is responsible, it may be fined up to $500,000 and/or six years imprisonment. One exception to the plastic disposal requirements of Annex V is the accidental loss of synthetic fishing gear incidental to its repair, as long as reasonable precautions to avoid such loss have been taken (Koehler et al., 2000).

D. Net Disposal and Recycling

Under MARPOL, all ports, terminals, or marinas, whether public or private, are required to provide trash reception facilities for wastes generated at sea and are responsible for the handling and disposal of the wastes once received.

In 1987, the Port of Newport Oregon, with funds provided by the National Marine Fisheries Service, began a one-year pilot project to help provide fishermen with convenient refuse disposal facilities. Under this program recycling and re-use was encouraged, including a popular program that allowed fisherman to leave off unwanted trawl net for public re-use (as baseball backstops, gardening supports and erosion mats, jungle gyms, and the like). The other goals of this project were to increase public awareness about the problems caused by marine debris and to evaluate the program so that other ports could benefit from the Port of Newport's experiences.

Due to the positive response from the fishing community to this program and with the aid of Saltonstall-Kennedy funds, the Pacific States Marine Fisheries Commission (PSMFC) took on similar disposal, recycling, and awareness projects in other ports in Oregon, Washington, Alaska, and California. Gillnet recycling was initiated in Bellingham, Washington and Cordova, Alaska under this program and trawl and seine net "public re-use" was encouraged in Seattle and Bellingham in Washington, and in Astoria and Coos Bay in Oregon. Gillnet recycling was further promoted by the PSMFC with a follow-up grant from the Environmental Protection Agency (EPA). Seattle, Bellingham, Anacortes and Everett, Washington, Astoria, Oregon and Cordova, Naknek, Kenai, Dillingham, and Petersburg, Alaska participated in this Program (Recht, 2000).

The dockside recycling receptacles initially focused on bulky materials such as cardboard, wood (for re-use), metal, and nets (for re-use) as well as oil. Later, paper, aluminum, and other scrap metal recycling was promoted in Alaskan communities involved in gillnet recycling. These facilities not only provided convenient refuse disposal for the fishermen and provided a source of scrap materials, they helped gain the acceptance of the program by port officials by keeping port disposal costs down, especially in areas where recycling pick up services for oil, cardboard, and scrap metal exist kept logistics streamlined. In some areas, e.g., Alaska, where dump space is limited and the siting of new waste dumps costly, reduction in the amount of materials entering the waste stream was an additional

benefit. However a belief that recycling should 'pay for itself', an unrealistic expectation, moderated some community's commitment to the programs (Recht, 2000).

The recycling of gillnets has proven to be an economically viable operation and a benefit for the ports in several Alaska and Washington communities and thus has continued as a private enterprise relationship.

Though trawl net re-use is still promoted in a number of ports (e.g., Newport and Anacortes), no recycling has been workable, due to the low value of the polypropylene nets and the presence of gear such as chains and rollers, making the effort too labor intensive unless subsidized (Recht, 2000).

Due to re-prioritization of policy objectives and programmatic goals (e.g., EPA focus changed from recycling promotion to pollution prevention), additional funding to help develop, streamline, and coordinate these projects was not available after the initial funding ran out. While many of the Port's involved in this project continue the programs initially established and while the private recycler also helps to promote the effort, additional funding would have helped strengthen industry and community involvement and buy-in into the program and expand opportunities in other ports (Recht, 2000).

Skagit River Steel and Recycling, located in Burlington, Washington, is the only company currently involved in net recycling in the United States. This company works with ports in the Northwest and Alaska. The principal markets are in Hong Kong, Taiwan, China and Japan. Recently markets have begun to develop in the U.S.

The company deals almost exclusively with nylon nets: gillnet and driftnets. Past experience has shown recycling nylon seine nets can be economically viable. Many seine nets are coated to preserve and extend their life which complicates their recycling.

The synthetic materials used to construct trawl gear, polypropylene, and polyethylene is problematic for recycling because they degrade. If some type of photo-degradable material is added to synthetic trawl materials, it would further make trawl nets more difficult to recycle. Skagit River Steel and Recycling currently does not handle trawl gear. The company did handled trawl nets in the past but stopped doing so because it lost money.

One of the major obstacles is the need for consistent support for net recycling at the local level, whether it is a fisheries organization or local government. Another problem is the plastics market is very fickle (Hendrickson, 1999). The port of Newport, Oregon reportedly has made used trawl net available to the public for use in landscaping and for other purposes (Recht, 1999).

Carr and Harris (1997) report that in New England changes in minimum mesh size requirements forced fishermen to buy new gear and dispose of old nets. Many landfills reportedly were not willing to accept the old gear for disposal (Carr and Harris, 1997). Similarly, in the central western Pacific problems with disposal of worn out purse seine gear has led to some nations refusing to dispose of these nets in limited land fill capacity (McCoy, 1999). This presents a dilemma as to how to legally dispose of gear.

E. Industry Action

As noted, the MPPRCA requires all U.S. vessels greater than 40 feet, including commercial fishing boats to: (1) develop a written waste management plan that describes the procedures used by the vessel for handling the vessel's garbage in accordance with MARPOL Annex V laws, and (2) maintain a detailed waste logbook that details the handling and disposal of plastics and other wastes. These records must be maintained onboard the vessel for at least two years and are to be available to the USCG for inspection upon request.

In addition to compliance with MARPOL, the fishing industry has initiated a number of waste reduction programs and policies designed to prevent, reduce, and re-use vessels' wastes. Fishermen have taken a leading role in addressing the problem of marine debris and lost nets. The fishing industry has spent its own funds to produce educational materials such as posters and stickers intended to educate the public about the problem of marine debris. Fishermen have been actively involved in efforts to encourage ports to provide dockside waste disposal and recycling receptacles to facilitate the proper disposal of fishing gear (Leipzig, 2000). The fishing industry has organized and funded at least one major conference examining the problem of lost fishing gear.

In Kodiak and Dutch Harbor, Alaska, the fishing industry works closely with port authorities to ensure proper disposal of damaged and worn nets and vessel wastes. Approximately 800 tons of net are land filled every year in Dutch Harbor and Kodiak. In Kodiak, nets disposed in the landfill are buried. In Dutch Harbor nets are stockpiled while efforts to arrange for barge service to make annual trips to recycling centers are pursued. Kodiak makes used nets available to the public for a multitude of uses, including erosion control, landscaping, and pest control for gardens. The local Chambers of Commence have begun work on a feasibility study on burning used nets for power generation. In Kodiak, a program to recycle and re-use motor oil from vessels has reportedly resulted in savings of approximately $100 thousand a year on waste oil disposal. Some of the waste oil is used for heating purposes while the rest is recycled for re-use (Burch, 2000).

Some industry trade associations and vessels operators provide new crewmembers orientations that include a review of the requirements of MARPOL and company waste disposal policies. Some employee contracts also stipulate that the individual agrees to abide by all relevant laws and regulations, such as MARPOL and the MPPRCA. Most vessel operators, whether formally or informally, provide new crewmembers an orientation and overview of the policies and procedures they are expected to follow including waste disposal.

Some U.S. vessels operating in the North Pacific employ incineration as a waste management strategy. The Groundfish Forum is an industry trade association that represents nineteen of the twenty-five head and gut (H & G) catcher-processor vessels operating in the North Pacific. The average length of these vessels are 140 feet. Some of the vessels incinerate wastes at sea, including plastics. While most vessels employ burn barrels to incinerate wastes, a few vessels have incinerators on board. Incinerated ashes are brought to port for disposal (Henderschedt, 2000).

The fishing industry in Washington State is involved in several ongoing initiatives to

address the problem of lost fishing gear. Working with local dive groups, it has been involved in efforts to remove derelict gillnets from Puget Sound. A number of fishing vessel owners have donated their time and vessels as dive platforms to help remove these nets. Industry has initiated a program by which the location of lost nets in Puget Sound is provided to the Washington Department of Fish and Wildlife. The State reportedly is maintaining a database of this information and has produced maps showing the locations of nets (Zuanich, 2000).

The participants of the North Pacific Rim Fishermen's Conference on Marine Debris (1987) drafted and adopted the "Fishermen's Pledge to a Clean Ocean" (Appendix 1). The pledge is a commitment to: return all discarded fishing gear and other plastics to port and dispose of them properly; to make every effort to prevent accidental loss of fishing gear, make an effort to safely collect lost fishing gear found at sea return it to port for proper disposal; to follow the marine debris regulations required by MARPOL Annex V; and encourage all fishermen to follow this example. This pledge was distributed to fishermen as a plaque suitable for mounting on a vessel's bulkhead.

Many Japanese longline vessels operating in the Pacific, which typically average between 150 to 180 feet in length, are equipped with incinerators. Items not suitable for incineration are bundled for disposal at port (Araki, 2000).

Toppings et al. (1997) studied the waste disposal practices of fishing vessels on the East Coast of Canada in 1990 and 1991. Their study examines several industry actions and practices for managing wastes including damaged and worn gear. During the early 1990's, the Nova Scotia Maritime Fishermen's Union worked to encourage fishermen to bring their waste back to port. One of the major goals of this project, supported by Environment Canada, was to educate the fishing industry about the problem of marine debris. Another goal was to ensure that adequate disposal facilities, (e.g., barrels and dumpsters) were provided by various ports. In response, several Canadian fishing corporations reportedly initiated company policies prohibiting the discharge of their vessels' wastes at sea (Topping et al., 1997).

Toppings et al. (1997) reports that many of the non-U.S. fishing vessels operating off the Atlantic coast, particularly large factory trawlers of the former Soviet Union, incinerate their wastes. The authors note that Canadian vessels do not incinerate their waste because they are smaller vessels and Canadian law requires expensive air pollution reduction control equipment for operations that incinerate their waste.

In 1992, the United Nation's Conference on Environment and Development introduced the concept of responsible fisheries. Subsequently, the Food and Agriculture Organization (FAO) of the United Nations elaborated the concept in the "Code of Conduct for Responsible Fisheries," which was adopted in 1995. Compliance with the Code is voluntary.

The FAO Code of Conduct proposes inter alia the following actions to prevent marine pollution: (1) nations should introduce and enforce laws and regulations based on MARPOL; (2) fishing vessel owners and operators should fit their vessels with appropri-

ate equipment as required by MARPOL and consider fitting a shipboard compactor or incinerator if possible to treat garbage and other shipboard wastes generated during normal vessel operations. In addition the Code of Conduct recommends efforts be made to develop new technologies, methods and materials to reduce the loss of fishing gear and reduce the impacts of lost or abandoned gear (FAO, 1995).

The associated technical guidelines for responsible fisheries contain the following recommendations to reduce marine debris:

Vessels should attempt to recover all lost fishing gear and when not possible, report the type, extent, and position of the lost gear. In the event that any lost gear is encountered, it should be recovered if possible and returned to port. Again, if this is not possible the position and type of gear should be reported.

- Fishing gear should be marked in order to facilitate the identification of the owner.
- Attempts should be made to reduce conflicts between active and passive gear.
- When a fishing vessel fouls or interferes with gear that does not belong to it, it should take all practicable measures to minimize the extent of damage caused to the gear.
- All ports should be maintained and managed in such a manner as to ensure compliance with relevant marine pollution laws, particularly MARPOL Annex V.

Some segments of the fishing industry have endorsed the concept and principles of responsible fisheries. The Responsible Fisheries Society (RFA), an industry trade association affiliated with the National Fisheries Institute (NFI), has developed and adopted the "Principles for Responsible Fisheries." These principles are intended to provide guidelines to fishing and seafood firms and organizations to ensure responsible use of fishery resources and protect the environment. The groups that have adopted them are reportedly developing specific action plans to implement them.

3.0. UMMARY OF RECOMMENDATIONS FROM PREVIOUS CONFERENCES

Beginning in 1984 there have been several conferences convened to examine the issue of Marine Debris including the issue of derelict fishing gear. These include: the First International Conference on the Fate and Impact of Marine Debris, Honolulu, Hawai'i (Shomura and Yoshida, 1985); the North Pacific Rim Fishermen's Conference on Marine Debris, Kailua-Kona, Hawai'i (Alverson and June, 1988); an Interagency Task Force on Persistent Marine Debris, established by President Ronald Reagan in response to a letter from thirty U.S. Senators expressing concern about the growing problem of marine debris, published a report recommending various actions to address the problem (Cottingham, 1988); the Second International Conference on Marine Debris, Honolulu, Hawai'i (Shomura and Godfrey, 1990); and the Third International Conference on Marine Debris, Miami, Florida (Faris and Hart, 1995). Each of these group efforts produced a number of recommendations to address the problem of marine debris. The following recommendations, relevant to the fishing industry, are drawn from the previous conferences. Table 3 summarizes these recommendations.

First International Conference on Marine Debris (1984)

1. Undertake efforts to advise user and interest groups of the nature and scope of the marine debris problem. Such groups should include the fishing and plastics manufacturing industries, merchant carriers, the military, appropriate international groups, and the public.
2. Develop a means of identifying derelict gear through creation of a reference collection.
3. Obtain worldwide data on vessel disablement as a result of interactions with marine debris.
4. Develop alternative methods for both fishing and non-fishing activities to replace those methods that contribute significantly to the marine debris problem.
5. Investigate use of biodegradable materials in gear construction and the recycling of net materials.

North Pacific Rim Fishermen's Conference on Marine Debris (1987)

1. Tag fishing gear using the same technology as coded-wire tagged salmon.
2. Identify fishing gear and methods for which alternate materials or operating procedures may reduce their likelihood of becoming hazardous marine debris.
3. Assess the feasibility of and impediments to the recycling of waste fishing gear and other vessel-generated wastes.
4. Improve shore-side reception and management of vessel-generated wastes. In particular, to assist in the development of integrated waste management systems. This need is particularly acute in remote fishing communities.
5. Develop safe and effective shipboard incineration methods and other technologies for shipboard waste handling, storage, and transfer to shoreside facilities.
6. Examine cost-effective systems to facilitate the identification, recovery, and return of lost fishing gear to port or owners.
7. Quantify the economic losses to fishing and recreational vessels caused by marine debris.

Table 3. **Previous Conference Recommendations, Industry Actions**

	First International Marine Debris Conference (1984)	North Pacific Fishermen's Conference (1987)	Interagency Report on Persistent Marine Debris (1988)	Workshop on Derelict Fishing Gear (1988)	Second International Marine Debris Conference (1989)	Third International Marine Debris Conference (1994)
Recommendations						
Gear Modification	X		X	X	X	
Degradable Materials	X		X	X	X	X
Source Identification	X	X				
Economic Impacts	X	X	X		X	X
Education	X		X	X	X	
Gear Recycling	X	X	X	X		
Shoreside Disposal Methods		X				
Shipboard Disposal Methods		X				
Gear Recovery Methods		X	X			
Enforcement			X			
Gear Loss Reduction Methods		X	X		X	
Monitoring	X					
Regulatory Measures					X	X
Economic Incentives				X		

Report of the Interagency Task Force on Persistent Marine Debris (1988)

1. The U.S. Coast Guard should begin a public education campaign on the requirements of the Marine Plastic Pollution Research and Control Act as soon as possible to assure that owners and operators of all vessels, ports and the boating public are aware of requirements prior to enforcement.

2. The U.S. Coast Guard and other federal enforcement agencies should make enforcement of regulatory requirements of the Marine Plastic Pollution Research and Control Act a high priority.

3. NOAA should encourage regional fishery management councils to include requirements that fish and shellfish traps and pots have degradable panels or latches.

4. Federal agencies should work with state and local governments, universities, merchant vessel owners and operators, commercial and recreational fishermen, and local communities to quantify economic impacts caused by persistent marine debris.

5. NOAA should work with fishermen and equipment manufacturers to develop pragmatic ways to:
   a. reduce loss of fishing equipment, particularly traps, trawl nets, and gill nets;
   b. improve ways to recover lost fishing traps and nets; and
   c. recycle used fishing nets and nets fragments.

6. The National Bureau of Standards should work with the ASTM (formerly known as American Society for Testing Materials) and other industry associations to develop standards and criteria for what constitute bio-degradable and photo-degradable.

7. NOAA, EPA and FDA should work with plastics manufacturers to examine how degradable plastics react in the environment, including potential environmental effects as the plastic degrades.

Oceans of Plastics: A Workshop on Fisheries Generated Marine Debris and Derelict Fishing Gear (1988)

1. Explore financial incentive-based solutions for reducing gear discard and loss. These could include net deposits, gear inventories, and bounty systems.

2. Pursue programs to educate the public and users groups to help reduce marine plastic debris.

3. Pursue technological solutions to reduce marine plastic debris including the use of degradable plastics in packaging as well as in fishing gear, recycling plastics and marking nets at the time of manufacture to identify owners at some point in the future.

Second International Conference on Marine Debris (1989)

1. Pursue technological and procedural solutions to the marine debris and solid waste problems while avoiding policies and regulations that may restrict solutions.

2. Expand marine debris and solid waste disposal education to people and institutions worldwide, recognizing regional and cultural differences in the perception of these problems.

3. Design and implement experiments to evaluate ghost fishing in gillnet and trap fisheries with high gear loss rates, developing mitigative measures as needed.

4. Evaluate the economic impacts of marine debris, both direct, as in vessel disablement and commercial fish loss, and indirect, as in aesthetic damage and solution costs.

Third International Conference on Marine Debris (1994)

1. Research and implement mechanisms to reduce fishing gear loss. These could include technological changes in gear design or incentives to recover lost gear. Given the appropriate incentives, the collection of derelict gear may be feasible.

2. Establish an impact reporting system to promote and collate observations by beach users, fishermen, oceanographers, scuba divers, and others. Start by compiling past records.

3. Make efforts to recover lost fishing gear in areas where it is likely to be concentrated. Also, take steps to better evaluate the kinds and amounts of fish caught and the potential effectiveness of such work to clean up hazardous ghost fishing gear. Establish a system to record gear loss by commercial fishermen.

Table 4 provides a summary of comments received from several Pac-Rim nations concerning the types of ongoing governmental and industry programs and actions needed to deal with the issue of derelict fishing gear.

Table 4. **Summary of Governmental and Industry Actions for Derelict Fishing Gear**

	Nation					
	Cook Islands[1]	Fiji[2]	Japan[3]	Philippines[4]	Korea[5]	Taiwan[6]
Recommendations						
Degradable Materials					X	
Education	X	X	X	X		X
Gear Recycling	X			X	X	
Shoreside Disposal			X	X	X	X
Shipboard Disposal Methods			X			
Gear Removal & Recovery Methods					X	X
Enforcement	X	X	X			
Gear Loss Reduction Methods					X	X
Monitoring		X		X		
Regulatory Measures	X	X				X
Gear Marking				X		
Industry Code of Conduct	X					
Regional/International Cooperation	X	X				
Gear Restrictions	X	X				X
Clean-ups					X	

1. Ministry of Marine Resources, Cook Islands
2. Ministry of Agriculture Fisheries and Forests, Fisheries Division, Fiji Islands
3. Office of Ecosystem Conservation, Resources and Environmental Research Division, Fisheries Agency Government of Japan
4. Bureau of Fisheries and Aquatic Resources, Republic of the Philippines
5. Ministry of Maritime Affairs and Fisheries, Republic of Korea
6. Fisheries Administration, Republic of China

4.0. POTENTIAL TOPICS FOR WORKING GROUP DISCUSSION

A. Gear Modification

1. Degradable materials

Synthetic fibers currently used in fishing gear construction degrade primarily due to exposure to UV radiation from sunlight and heat. As the material degrades it becomes more susceptible to microbial degradation. While the technology exists to chemically modify plastics to accelerate degradation and decomposition very little is known about the effectiveness of these techniques in the marine environment. Degradable escape panels are widely used in crab, lobster, and shrimp traps. The cost of degradable materials that could potentially be used in fishing gear construction remain significantly higher than those synthetic fibers currently used (e.g., nylon and polyethylene). Questions remain about both the performance and safety of degradable plastics in fishing gear construction (Andrady, 2000).

2. Lightstick modifications

Lightsticks are lost during the course of normal longline fishing operations. Lightsticks are positively buoyant and if ingested by marine mammals, seabirds, or marine turtles can cause health problems. Proposed solutions to the problem have included requiring a deposit for lightsticks, increasing the length of the light stick to make it more difficult for marine life to ingest and developing sinking light sticks.

Lindgren and Pittman, a major manufacturer of lightsticks used in longline fisheries, has developed a battery-powered sinkable light stick. While initially more expensive than disposables, it is estimated that over time the costs will be cheaper than chemical disposables. Based on initial trials conducted in Florida there may be an increase in catch rates associated with the new lightsticks.

B. Gear Marking

1. Gear Marking

The concept of marking fishing gear during manufacture for future identification has been proposed. The marking of nets through the use of some type of tracer has been proposed as a mains to help identify and reduce sources of lost fishing gear. Concerns have been expressed about the concept. During the lifetime of a net it may be sold, traded, or loaned and thus used by multiple vessels. Another consideration is the long residency time of lost fishing gear in the marine environment. Recovery of lost fishing gear may not occur until years after its loss. The vessel operator that lost or discarded the gear may no longer be involved in fishing. Gear marking is a potentially useful tool to help focus prevention, reduction, and enforcement efforts on specific domestic and international sources of derelict fishing gear.

2. Color coding trawl web

Developing a color coding system to has been proposed as one possible means to identify sources of derelict webbing. In addition to the fishing industry, merchant shipping reportedly uses webbing that is indistinguishable from that used in some fishing net construction.

C. At-sea Disposal Systems
The U.S. Navy has spent millions on developing vessel disposal systems for waste. The problem is scaling these systems down to a typical commercial fishing vessel. Some systems require more power than available on average commercial vessels. Some of the large, factory vessels might be able to accommodate the waste disposal systems developed by the Navy. The Government of Japan has provided support for the installation of on-board incinerators by the fishing industry.

At sea disposal systems include incinerators, burn barrels, and compactors. A number of issues related to the use of the type of disposal methods include safety, effectiveness, and costs.

D. Education and Outreach
Educational programs, designed to inform all user groups and the public, have wide support among the fishing industry. Education is seen as one of the most effective means of influencing members of the public including fishermen (Anonymous, 1988).

E. Enforcement
Enforcement of MARPOL is difficult. Nonetheless, the USCG has vigorously pursued enforcement of the law. Fines for MARPOL violations are high and have served as significant determent to the illegal disposal of nets and other plastics by fishing vessels. Review and inspection of fishing vessels waste management plans, procedures, and logbooks by the USCG has led to enhanced compliance with MARPOL by the fishing industry.

F. Fishing Gear Disposal
Net disposal and recycling programs have proved popular with fishermen and have generally received industry support where implemented.

G. Economic Incentives
Providing economic incentives to help prevent and reduce the problem of derelict fishing gear has been proposed. Possible incentives include gear deposits, inventory, and bounties for lost gear.

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Appendix 1.

"Fisherman's Pledge For a Clean Ocean"

I recognize that a clean, productive ocean is necessary for the livelihood of fishermen throughout the world.

I realize that pollution and marine debris, particularly plastics, threaten marine life and my safety at sea.

Therefore, I pledge to:

Return all discarded fishing gear and other plastics to port and dispose of them properly;

Make every effort to prevent accidental loss of fishing gear;

Make an effort to safely collect others' lost fishing gear and debris I find at sea and return them to port for proper disposal;

Follow the marine debris regulations required by the international treaty, MARPOL Annex V; and

Encourage all my fellow fishermen to follow my good example.

Through these actions I will preserve a clean ocean today and for fishermen of the future.

MITIGATION OF ENVIRONMENTAL IMPACTS OF DERELICT FISHING GEAR THROUGH DEBRIS REMOVAL AND ENVIRONMENTAL MONITORING

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BACKGROUND

Prior to the 1950s, discarded or lost fishing gear posed little long-term environmental threat, as nets were almost exclusively composed of natural fibers (linen, cotton, jute, hemp, manila, and sisal) susceptible to environmental degradation (Uchida, 1985). Nylon webbing first appeared in Japanese nets in 1949, and by 1964, 95% of nets produced in Japan were composed of synthetic fibers (Japan Chemical Fibers Association, 1971). Currently, almost all of the fishing gear in developed countries is composed of durable synthetic fibers (Klust, 1973). The production and availability of synthetic fibers, coupled with mechanization and echo sounding, revolutionized the fishing industry (Kristjonsson, 1959) by producing nets that were functionally impervious to degradation (Andrady, 1990). The durability of fishing gear composed of synthetic fibers, when discarded or lost, generates persistent waste in the marine or littoral environment.

Fishing gear loss appears to be increasing as a result of economic pressures that have contributed to modifications in fishing operations and efforts in a wide variety of fisheries (Carr and Harris, 1997). Carr and Harris (1997) link dwindling target stocks, advances in equipment handling and materials technology, solid waste disposal limitations and loss reimbursement programs to increased potential for fishing gear loss or discard. Estimates of gear loss have primarily been inferred based on fishery effort, limited fishery observer data or beach surveys, with much emphasis on the Pacific region. Uchida (1985) reported that in the mid-1980s, 170,000 km of gill net, 2,000 km of purse seine, 5,500 km of trawl net and 8,900 km of miscellaneous net gear were available to North Pacific net fisheries and provided this as an estimate of the size of the source from which derelict fishing gear was generated. Uchida (1985) speculated that gear losses were highest in the gill net fisheries, followed by trawl fisheries and set net fisheries. Low et al. (1985) utilized observer data to generate minimum estimates of gear loss in Alaska trawl fisheries from 1954 to 1983, which they reported at sixty-five nets total. Sighting surveys conducted in the North Pacific from 1986 to 1991 identified two regions of high derelict fishing net density, 20 to 30 N, 150 to 130 W and 30 to 40 N, 140 to 150 E (Matsumura and Nasu, 1997). A significant

high density area of derelict fishing gear was also reported northeast of Hawai'i by Mio et al. (1990). Kubota (1994) proposed a convergence zone associated with the North Pacific subtropical high as a mechanism for the disproportionate accumulation of marine debris from the greater North Pacific in the area north of Hawai'i. Recent oceanographic measurements support Kubota's model (see Brainard et al., 2000) and suggest a non-homogenous distribution of marine debris. The amount of derelict fishing gear accumulating in this region has not decreased since the early-1980s, despite the ratification of MARPOL Annex V (1973/1978) by the majority of the world's fishing nations (Henderson, in review).

Derelict fishing gear, once in the marine and littoral environment, has widespread environmental and economic impacts. One hundred thirty-six species of marine animals have documented records of entanglement in marine debris, including numerous threatened and endangered species (Laist, 1996). Eighty-six percent of the world's sea turtle species and 28% of the world's marine mammal species, as well as seabirds, fish, and crustaceans have been recorded entangled in derelict fishing gear. Mortality resulting from entanglement in fishing gear has been proposed to explain population level declines in the northern fur seal (Callorhinus ursinus), a seal listed as depleted under the Marine Mammal Protection Act of 1973 (Fowler et al., 1990). The critically endangered Hawaiian monk seal (Monachus schauinslandi) suffers the greatest entanglement rate of any pinniped (seal or sea lion) reported to date, nearly twice that of the northern fur seal (Henderson, in review). Derelict fishing gear may also negatively affect target stocks, as well as noncommercial species, by continuing to fish after becoming lost or discarded, thus removing animals otherwise potentially available to active fishing operations. The greatest potential for this "ghost-fishing" is associated with gillnets, followed by trap or pot gear (Carr and Harris, 1997). Derelict fishing gear may also function as a vector for the introduction of alien species. As nets circulate around ocean gyres they are subject to colonization by encrusting, epibiont, or other biota and may subsequently transport these organisms to novel environments (Winston et al., 1997). Recently, derelict fishing gear has been identified as a direct threat to coral reef ecosystems through the abrading and scouring of coral substrate, as circulating nets snag on shallow reefs (Brainard et al., 2000; Donohue, unpublished data).

Here we briefly review recommendations pertaining to debris monitoring and removal from previous meetings, followed by a discussion of survey techniques used to monitor marine and littoral environments for derelict fishing gear. We also describe selected methods employed to remove derelict fishing gear from these environments. Lastly, we discuss the use of remote-sensing technology to aid in the prediction of areas where marine debris is likely to accumulate, and the potential utility of remote-sensing technology to monitor and manage ecosystem health, including marine debris burden. We hope this abridged summary will stimulate further discussion on the monitoring and removal of derelict fishing gear and direct the reader to the primary literature for additional detail.

SUMMARY OF PREVIOUS CONFERENCE RECOMMENDATIONS

Over the past 16 years, several international meetings have convened to address the problem of marine debris in the world's oceans. These included the Workshop on the Fate and Impact of Marine Debris (1984, Honolulu, HI), The North Pacific Rim Fishermen's Conference on Marine Debris (1987, Kailua-Kona, Hawai'i), The Second International

Conference on Marine Debris (1989, Honolulu, Hawai'i) and The Third International Conference on Marine Debris (1994, Miami, Florida). In addition, The Alaska Sea Grant College Program, under the direction of the United States National Oceanic and Atmospheric Administration (NOAA), Office of the Chief Scientist, published a Report of the Interagency Task Force on Persistent Marine Debris in 1988. Selected fishery-related recommendations and conclusions from these meetings are presented in Appendix 1.

Despite the passage of over sixteen years since the first workshop, the recommendations and conclusions of subsequent meetings with regard to monitoring and removal (mitigation) of marine debris are notably consistent. Certainly, in part, this speaks to the wisdom of early conference and task force participants in identifying seminal conclusions and recommendations that have remained relevant. Equally as certain, the persistence of recommendations and conclusions over time reveals both the need for continued monitoring, and increased mitigation, of this persistent problem. Following are synopses of the four most frequently cited recommendations and conclusions from previous meetings with specific regard to environmental monitoring and marine debris removal:

1) **Identify the distribution, abundance, density, and type of persistent debris in the marine environment.**
   The first Workshop on the Fate and Impact of Marine Debris (Shomura and Yoshida, 1985) affirmed the widespread occurrence of debris of terrestrial and aquatic (shipborne) origins in the marine environment and concluded that research on marine debris distribution was needed. Subsequent conferences reiterated the need for research to enhance understanding of marine debris dynamics in the world's oceans to facilitate mitigation efforts (Shomura and Godfrey, 1990; Alverson and June, 1988; Coe and Rogers, 1997; Faris and Hart, 1995). Specifically, information on distribution, abundance, density, and macro- and meso-scale movements of marine debris were deemed incomplete. Also noted was the paucity of information on marine debris in oceanic regions other than the North Pacific (Shomura and Yoshida, 1985; Alverson and June, 1988).

2) **Determine the fate of persistent debris in the marine environment.**
   Where marine debris is present, it poses variable risks depending on its persistence in the marine or littoral environment. Further, the susceptibility, or lack thereof, of plastic debris to nonchemical deterioration and chemical degredation (bio-, photo-, thermooxidative and hydrolytic; see Andrady, 1990) affects its potential for environmental damage such as ghost fishing, entanglement and ingestion by wildlife, and substrate damage. Recommendations for research pertaining to the fate of marine debris were presented at the 1984 Workshop on the Fate and Impact of Marine Debris (Shomura and Yoshida, 1985) and reiterated in 1994 at the Third International Conference on Marine Debris (Coe and Rogers, 1997; Faris and Hart, 1995).

3) **Recover (clean) marine debris from the marine and littoral environment.**
Once in the marine environment, the recovery of debris is the most straightforward mechanism to mitigate environmental damage. The North Pacific Rim Fishermen's Conference on Marine Debris advocated an examination of cost effective systems to facilitate the recovery and return of lost fishing gear (Alverson and June, 1988). The Interagency Task Force on Persistent Marine Debris recommended that U.S. NOAA collaborate with fishermen and equipment manufacturers to develop pragmatic ways to improve recovery of lost fishing gear (Alaska Sea Grant, 1988). Recovery of lost gear, through incentives or other means, and the evaluation of the effectiveness of efforts to clean up ghost nets were included in recommendations of the Third International Conference on Marine Debris (Coe and Rogers, 1997; Faris and Hart, 1995).

4) **Conduct research on environmental impacts of marine debris.**
Efforts to establish, and continue, examinations of the effects of marine debris on the environment have been repeatedly recommended. Early recommendations sought to document evidence of wildlife interactions with debris (Shomura and Yoshida, 1985). Subsequent conclusions advocated increased support of studies of entanglement of wildlife in marine debris, particularly threatened, endangered or depleted species (Alaska Sea Grant, 1988; Shomura and Godfrey, 1990). Also noted was the need to investigate impacts of persistent debris ingestion on such organisms as seabirds, marine turtles, and marine mammals (Shomura and Godfrey, 1990; Coe and Rogers, 1997; Faris and Hart, 1995). The Third International Conference on Marine Debris included discussion on the potential for the introduction of alien species by marine debris and recommended investigations addressing this concern (Coe and Rogers, 1997; Faris and Hart, 1995).

DERELICT FISHING GEAR MONITORING AND REMOVAL ACTIONS

Beach Surveys

The first systematic assessments of derelict fishing gear resulted from beach surveys, which continue to provide valuable information on the prevalence of derelict fishing gear (see Ribic et al., 1992). These studies are often a more cost effective way of monitoring debris trends than at-sea efforts, and may be completed concurrently with environmental monitoring of wildlife populations (Torres et al., 1997; Hucke-Gaete et al., 1997; Henderson, in review). Ribic and Johnson (1990) classify beach surveys as either beach-focused or ocean-focused. Beach-focused surveys estimate the amount of debris on a specific beach at a specific time. Ocean-focused surveys examine trends in marine debris on specific beaches over time as an indicator of oceanic conditions. Ocean-focused surveys have provided important information on large or very large derelict fishing gear (nets and rope) trends. If derelict fishing gear is removed from beaches during these studies, mitigation of further environmental damage, such as wildlife entanglement, is possible.

An opportunistic study on Alaska's Amchitka Island was begun in 1972 by Theodore Merrell of the U.S. National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS). The majority of anthropogenic debris on Amchitka Island was composed of derelict fishing gear components (Merrill, 1985). Over time, the focus of this project evolved from the amount and type of debris present to the use of trawl web dynamics to assess the impacts of MARPOL Annex V (for a more detailed

chronology of this study see Ribic et al., 1992). Derelict fishing gear on these beaches was routinely removed in later years of the study (Ribic et al., 1992).

Beach surveys of derelict fishing gear on the remote Northwestern Hawaiian Islands (NWHI) from 1982 to 1986 documented the presence of 773 net or net fragments and were completed in conjunction with studies on entanglement rates of the endangered Hawaiian monk seal (Henderson, unpublished data). Recently, Henderson (in review) reported no decline in the amount of derelict fishing gear on the NWHI from 1982 to 1999, suggesting a failure of MARPOL Annex V to reduce the impacts of derelict fishing gear in this region. Until the late-1990s, derelict fishing gear was regularly burned on the beaches of these atolls to reduce the entanglement hazard to monk seals and other wildlife. Subsequently, due to concern over toxic byproducts, burning of debris was restricted in areas under the jurisdiction of the U.S. Fish and Wildlife Service, tasked with management of the Pacific Remote Island National Wildlife Refuges. Presently, derelict fishing gear that accumulates on these islands is analyzed and stored in bins and later removed to ships by a multi-agency partnership led by the U.S. NMFS. In 1999 alone, 12,500 pounds of derelict fishing gear were removed from the beaches of just two NWHI (Donohue, unpublished data).

Slip and Burton (1991) examined the beaches of two islands in the Southern Ocean, Heard Island and Macquarie Island. Heard Island, in the Indian Ocean sector, is near fisheries supported by the Kerguelen Plateau (Williams, 1988). Macquarie Island is in the Australasian sector, which does not support a regional fishery. Fishery related debris accounted for 40% of all artifacts at Heard Island and 29% on Macquarie Island.

Beach surveys for marine debris have also been conducted in other regions, most often coupled with cleanup efforts. These beach cleanups have been conducted in the USA, the UK and Australia, often relying on volunteers and conducted near metropolitan centers (Jones, 1994; Ribic et al., 1996; Rees and Pond, 1995). For example, in Australia, fishing debris accounts for 2%-41% of the total debris on beaches (Slater, 1991; Edwards et al., 1992; O'Callaghan, 1993; and see Jones', 1994 review). Derelict fishing gear is also a notable component of beach surveys for marine debris in Puerto Rico, Mexico and Barbados (Coe et al., 1996).

Concerns associated with beach surveys include logistical limits to geographical areas surveyed or cleaned, potential inherent biases associated with differential fates of marine debris types at sea (Dixon and Dixon, 1981a) and inconsistent or statistically weak sampling designs which prevent meaningful comparisons between efforts. Nevertheless, beach surveys for derelict fishing gear provide valuable information, particularly where a time series of data exist, and provide a mechanism for large numbers of the public to involve themselves in marine management issues. Lastly, volunteer beach cleanups are the primary mechanism for the removal of marine debris from the littoral environment.

Shipboard Sighting Surveys

Shipboard sighting surveys for the assessment of marine debris distribution and amount consist of visually inspecting the ocean surface for floating debris. This method is particularly suited for medium to large derelict fishing gear items (see Ribic et al., 1992 and Hess et al., 1999), and requires dedicated or opportunistic sea craft, good visibility and favorable

weather. Observers stationed on the flying bridge or other elevated sections of the ship visually search for debris items in strip or line transects. During strip transects, debris items are counted on the side of a ship within a specified distance, commonly ranging from 50 m (Day and Shaw, 1987; Day et al., 1990a) to 100 m (Dixon and Dixon, 1983). During line transects all debris items visible are counted regardless of their distance from the ship. When the perpendicular distance of the objects to the ship can be accurately measured, the line transect method is preferable (Ribic, 1990; Burnham et al., 1985). Platforms of opportunity are often used as a result of cost constraints and thus the sampling area, the height of the observer above the water, ship speed, etc. may not be controlled by the researcher. These factors affect the accuracy of the assessments (Mio and Takehama, 1988; Ribic et al., 1992). Furthermore, as the characteristics of the debris (size, color, buoyancy, shape) affect its visibility to surveyors, accurate characterization of debris is not readily accomplished (Mio and Takehama, 1988).

Despite these challenges, numerous informative sighting surveys have been completed. Dedicated vessels combined with vessels of opportunity have been used in Pacific-wide surveys conducted by the Fisheries Agency of Japan from 1986 to 1991 (Matsumura and Nasu, 1997). Matsumura and Nasu (1997) reported derelict fishing net density to be relatively higher in the midlatitudinal area of 20 to 30 N, 150 to 130 W of the eastern Pacific Ocean. They also noted a high density of derelict fishing nets on the Pacific Ocean side of Japan from 30 to 40 N, 140 to 150 E. The distribution of derelict fishing gear other than nets was found to have a wider general distribution, with the greatest densities (greater than 120 pieces per 100 square nautical miles) found from 25 to 35 N, 130 to 180 W. Mio et al. (1990) and Mio and Takehama (1988) previously reported a high-density area of derelict fishing nets northeast of Hawai'i during sighting surveys conducted in 1986. Day and Shaw (1987) also completed a multiple year study in the Gulf of Alaska in 1984 and 1985. Other baseline studies have been conducted in the North Pacific (Dahlberg and Day, 1985; Ignell, 1985; Jones and Ferrero, 1985; Ignell and Dahlberg, 1986; Day et al., 1990; Shaw, 1990). Additional regional sighting surveys were conducted around the Pribilof Islands in the Bering Sea, the main breeding islands of the northern fur seal (Callorhinus ursinus) (Yoshida and Baba, 1985; Baba et al., 1988, 1990). Fewer sighting surveys for marine debris have been completed in oceans other than the Pacific; however, the North Sea and Mediterranean Sea have been surveyed using vessels of opportunity (Dixon and Dixon, 1983 and Morris, 1980, respectively). Removal of derelict fishing gear is not a customary component of sighting surveys.

Shipboard Trawl Surveys

Shipboard trawl surveys can be used to survey marine debris on the surface of the water or on the seafloor. Neuston-type nets can be used to sample small floating marine debris and larger nets can be deployed to sample debris that has sunk to the benthos (Ribic et al., 1992). The latter are useful for the assessment of medium to large derelict fishing gear items. Trawling techniques mimic those used for fishing, with the net deployed to sample or "catch" debris resting on the seabed (see Ribic et al., 1992). The mesh size of the net used determines the minimum size of debris that may be caught. Thus, when comparing trawl-sampling studies, mesh size must be accounted for in the interpretation of results. Other factors that may affect trawl-sampling studies include vessel variability, weather, footrope variability, depth variability and measurement variability (Ribic et al., 1992).

Trawl sampling studies may be conducted opportunistically in association with commercial, experimental, or managed fisheries or with dedicated cruises targeting marine debris. The common occurrence of marine debris in benthic trawls on the continental shelf of the Northeast Gulf of Alaska was reported as early as 1976 (Jewett, 1976). Bering Sea fishing areas were also found to have greater amounts of benthic debris than areas not fished (Feder et al., 1978). More recently, working with the Alaska Department of Fish and Game, Hess et al. (1999) investigated fishery-related items caught during benthic trawls to survey crab and groundfish resources around Kodiak Island, Alaska. In the three years of their study, fishery-related items comprised 46%, 42%, and 38% of the total benthic debris recovered. Fishery-related debris densities ranged from 4.5–25.0 items/km2. After evaluation of fishery effort near Kodiak Island, and the subsample of fishery-related debris deemed potentially harmful to wildlife by the investigators, Hess et al. (1999) concluded that annual benthic trawl surveys for debris around Kodiak Island were unwarranted. The debris densities reported by Hess et al. (1999) were less than those reported for other benthic trawl surveys in the Bay of Biscay (203 items/km2; Galgani et al., 1995a) and on the continental shelf of the Western Mediterranean Sea (1935 items/km2; Galgani et al., 1995b) and were between those reported by June (1990) for the Eastern Bering Sea (2–7.5 items/km2) and off the Oregon Coast (150 items/km2).

Although shipboard trawl surveys have been used most extensively for surveying benthic marine debris, they cannot be employed in very shallow waters, on steep slopes or in sea canyons. A result of the shipboard trawl survey technique is the removal of sampled derelict fishing gear from the environment. Shipboard trawls have not been used in dedicated cleanup efforts.

Benthic Diving Surveys

Other methods investigated or proposed to survey benthic marine debris involve submersibles, towed camera systems and divers. The latter is the main focus of this section, as diving survey and removal efforts have recently been particularly successful for removing large amounts of derelict fishing gear from coral reef environments of the NWHI (Donohue, unpublished data). The cost and availability of manned submersibles and remotely operated vehicles (ROVs) have limited their use in marine debris surveys (Ribic et al., 1992). A manned submersible equipped with an external-mounted video camera was used by Carr et al. (1985) to survey commercial gillnetting sites in 1984. Carr et al. (1985) surveyed over 40.5 ha and documented ten derelict gill nets. Galgani and Andral (1998) investigated the use of a towed camera array to survey benthic marine debris, but the inability to quantify small debris items and difficulties with the deployment and positioning of the array prevented its successful use.

Diving surveys for benthic marine debris have not been widely conducted, but have recently been utilized extensively in the NWHI. Carr et al. (1985) used scuba divers to monitor the ghost-fishing of a simulated derelict gill net set in Cape Cod Bay. Benthic debris in McMurdo Sound, Antarctica, was also documented with divers (Lenihan et al., 1990).

A large-scale project utilizing divers to conduct surveys for, and remove, derelict fishing gear in the NHWI began with a pilot study in 1996 (Boland, unpublished data). The U.S. NMFS Honolulu Laboratory identified marine debris of a maritime origin, particularly derelict fishing gear, as a threat to the coral reef ecosystems of the NWHI (Brainard et al., 2000; Henderson, in review). In 1996 and 1997, the U.S. NMFS Honolulu Laboratory refined diver survey and removal techniques, removing 10,000 pounds of derelict fishing gear from the shallow coral reefs of the NWHI (Boland, unpublished data). In 1998 and 1999, the U.S. NMFS Honolulu Laboratory expanded efforts by partnering with a consortium of state, federal, and private organizations. Presently, the U.S. NMFS leads annual multi-agency, multiple ship efforts to survey and remove derelict fishing gear from the NWHI. The distribution, density, type, and organic fouling of derelict fishing gear is documented using snorkel divers towed in systematic parallel track survey transects behind small boats. Debris is documented using a global positioning system (GPS) and still and video photography. Derelict fishing gear is subsequently recovered using small boats and snorkel and scuba divers supported by U.S. NOAA and U.S. Coast Guard vessels. In 1999 alone, 18,500 pounds of derelict fishing gear was recovered from the NWHI coral reefs (Donohue, unpublished data). To date, over 77,000 pounds of derelict fishing gear have been recovered from the NWHI by these efforts (Boland, unpublished data; Donohue, unpublished data). Coral reef debris density ranged from 1.0–62.2 items/km2 (Donohue, unpublished data).

Human divers can execute surveys for derelict fishing gear in areas too shallow to employ submersibles or ROVs, and where seabed topography restricts trawl surveys (Ribic et al., 1992). Furthermore, human divers can remove derelict fishing gear from the substrate in a surgical fashion, reducing additional environmental damage to reefs during removal. Small sea craft towing divers can be deployed from ship platforms at oceanic sites or from land-based laboratories for coastal surveys. Diving surveys are most easily executed in benign climates and relatively shallow waters where diver safety can be maximized.

Drawbacks associated with the use of divers to survey and remove marine debris include expense, logistics, reliance on favorable weather, and good water visibility. Although supported through in-kind contributions, the thirty-day multi-agency derelict fishing gear survey and removal effort in the NWHI in 1999 cost in excess of one million U.S. dollars. These costs include two large ship platforms for housing and deploying divers and small boats, transport of recovered debris back to Honolulu, Hawai'i. Once derelict fishing gear is recovered it must be disposed of properly at port either through landfill, incineration, or recycling. Additionally, in ecologically sensitive areas where endangered or protected species occur, studies must be planned so as to minimize impacts to wildlife.

Remote-Sensing/Oceanography

Recently, the utility of remote sensing to monitor and assess marine debris has been investigated. Over the past two years, the U.S. NOAA Fisheries and NOAA CoastWatch oceanographers have been developing methods to apply knowledge of oceanographic processes and use of satellite remote sensing of ocean surface properties to identify and monitor regions where derelict fishing gear and other forms of marine debris would most likely accumulate (see Brainard et al., 2000).

Using an array of satellite environmental sensors, oceanographers are now able to observe properties of the ocean surface with much improved spatial and temporal resolution. These properties include surface winds (QuikSCAT and other scatterometers), sea surface temperature (AVHRR and GOES), sea surface height and computed geostrophic currents (TOPEX/Poseidon) and ocean color or chlorophyll (SeaWiFS and earlier CZCS). With these modern tools, scientists are now better prepared to assess the extent of the threat posed by marine debris over the vastness of the global ocean.

Using high-resolution scatterometer winds to compute wind stress curl over the Pacific Ocean, Brainard et al. (2000) have confirmed and expanded upon Kubota's (1994) finding of a marine debris accumulation region centered north of the Hawaiian Islands. Regions of oceanic convergence are most likely to accumulate marine debris while regions of oceanic divergence are least likely to accumulate marine debris. Brainard et al. (2000) found oceanic convergence to be highly nonstationary with pronounced seasonal and interannual variability. Convergence in the North Pacific is highest along the subtropical front in the western half of the basin during the winter months. In the vicinity of the NWHI, and in the main Hawaiian Islands, accumulation would be expected to be highest to the northwest and lowest to the southeast. During the summer, convergence is generally much weaker and more diffuse across the North Pacific with the region of highest convergence shifted to the eastern portion of the ocean basin several hundred miles off the California and Oregon coasts. The region of high convergence, or likely accumulation of marine debris, is strengthened and enlarged during periods identified as El Niño warm events in the tropical Pacific. During the 1992 and 1998 El Niño events, the region of convergence was observed to expand much further south to include the main Hawaiian Islands. This result partially explains the documented increase of marine debris found on beaches and reefs of the main Hawaiian Islands during 1998 (Brainard and Foley, unpublished data).

Presently, oceanographic knowledge and satellite observations of ocean conditions are being used to assist marine debris removal efforts by helping to locate areas in the NWHI and elsewhere that are most likely to have the highest concentrations of marine debris. From an oceanographic viewpoint, the coral reef ecosystems at Kure, Midway, and Pearl and Hermes Atolls are expected to have the highest average encounter rate of marine debris since these areas are more centrally located in the strongest mean convergence zone. Of course, bathymetry, reef structure and local processes such as small-scale flow regimes and wave forcing, also play a significant role in entangling debris on coral reefs and beaches.

These oceanographic analyses suggest that much lower accumulation rates of derelict fishing gear and other marine debris would be expected at most of the other tropical islands and atolls of the Pacific. Exceptions include the Japanese islands of the Ogasawara Archipelago, Kazan Group, and Minami-Tori, where moderately high accumulation rates might be expected. The same analysis predicted very low accumulation of marine debris in the U.S. Line and Phoenix Islands of the central equatorial Pacific; this was verified during a coral reef assessment cruise to these islands in March 2000 (Brainard, unpublished data). A similar analysis is currently underway for the entire Pacific basin (Brainard, unpublished data). Preliminary results indicate that wind-driven ocean convergence is less intense in the South Pacific Ocean. However, there are broad regions of

moderate ocean convergence, which may play a significant role in the transport and accumulation of marine debris. The utility of oceanographic analyses in other oceans to direct marine debris removal efforts should be investigated.

The removal of derelict fishing gear at sea, before it encounters reefs or damages wildlife, may be the most advantageous mitigation action once debris enters the marine environment. An ambitious proposal by the NMFS Honolulu Laboratory aims to investigate the feasibility of such efforts. Once the majority of the derelict fishing gear is removed from the coral reefs and beaches of the NWHI, Honolulu Laboratory scientists are proposing a comprehensive multi-agency program to begin removing marine debris at sea. By so doing, they hope to prevent much of the ecological damage, which is now threatening the coral reef ecosystems and protected species of the region. This plan takes advantage of the fact that ocean currents and convergence processes do an efficient job of accumulating marine debris from around the Pacific Ocean into relatively well-defined zones. Combining satellite observations of winds, sea surface temperatures (SST), ocean color and sea surface height, they believe they can identify general regions to direct aircraft and ships to interdict debris at sea. These regions of highest convergence would be along frontal zones of the order 100 km by 1000 km. These scales are well covered by satellite-based measurements. However, the oceanographic tools (e.g., SST, ocean color, and wind) are useful only for inferring likely positions; they do not have sufficient resolution to image the actual debris. Using aircraft equipped with synthetic aperture radar (SAR) or hyper-spectral visible light sensors, scientists could resolve scales less than 1 m, allowing them to map individual pieces of derelict fishing gear on the ocean surface (see below). This information would then be transmitted to surface debris removal vessels. Provided with maps of areas of highest concentration, the vessels could then use helicopters to guide them to individual derelict fishing gear items for at-sea removal. Although this multi-level scenario presently seems fanciful and costly, at-sea removal would potentially be no more expensive per ton of debris removed than the existing methodology of using divers to locate and cut away debris from the coral habitat.

Remote-Sensing/Geographic Information Systems (GIS)

Although significant efforts to find and remove derelict fishing gear have been ongoing for a number of years, particularly in the NWHI, traditional beach cleanups and ship-supported recovery efforts are limited to relatively small areas. For example, less than 5% by area of the NWHI reef habitat has been surveyed and even less of the habitat has been cleared of debris. To facilitate efforts to identify and remove derelict fishing nets from the NWHI management area, the NMFS Honolulu Laboratory has begun to investigate the use of remotely sensed imagery from a variety of sources linked with a broad range of other data (ocean winds and shear lines, field surveys, bathymetry, political boundaries) within a geographic information system (GIS). Remote imagery combined with in-situ survey data will be used to map and assess marine debris and to inform and improve debris removal efforts planned in 2000 and 2001. Although remote sensing has proved useful in a wide array of marine environmental applications, the ability to use imagery from a variety of airborne and satellite sensors to locate and identify derelict nets and other marine debris is unproved. Until recently, remote-sensing applications have been hampered by inaccurate base maps and low-resolution imagery available from U.S. government mapping agencies and satellite sensors. Full utilization of the GIS has been limited by the lack of accurate geographic data and limited amounts of marine debris survey data collected.

MITIGATION OF ENVIRONMENTAL IMPACTS OF
DERELICT FISHING GEAR THROUGH DEBRIS REMOVAL AND
ENVIRONMENTAL MONITORING

In 2000, a number of proposals to obtain high-resolution imagery from three separate sources have been submitted by NMFS Honolulu Laboratory and tentatively approved. As part of the Hawai'i Coral Reef Initiative, funding has been promised: (1) to obtain high resolution IKONOS satellite images of some of the NWHI that can be used to create valid base maps and assist in the identification and removal of marine debris, derelict nets particularly, that threaten the health of NWHI coral reef ecosystems, (2) to identify alien species that may be introduced to those ecosystems on such nets, and (3) to begin to develop a GIS-based remote sensing capability to monitor and model changes to shallow-water (<20 m) coral reef habitat in the NWHI. The privately owned and operated IKONOS imager satellite can provide 1 m resolution panchromatic and 4 m resolution multispectral (red, green, blue bands) imagery at 12 m horizontal and 10 m vertical accuracy with no ground control. With ground control stations, an exceptional 2 m horizontal and 3 m vertical accuracy can be attained. The IKONOS instrument can be tasked to provide complete coverage of the area, and if it can be used to identify derelict nets, will allow resources currently devoted to finding the nets to be dedicated to removing nets. Combined with other imagery and modeling efforts that have been successful in identifying wind convergence zones that influence the movement and accumulation of derelict nets (see previous section), the IKONOS imagery should be useful for identifying nets that are entangled on shallow reefs. At the resolution available with the IKONOS imagery, nets of ~2 m diameter should be identifiable if fieldwork is able to provide the necessary classification parameters. At minimum, this high-resolution imagery will be used to create accurate base maps of the land and emergent and shallow water (<20 m) reef areas of the NWHI. The major constraint on the use of IKONOS imagery is cost. Funding available this year will enable the acquisition of only three of the ten major reef areas of the NWHI. Through a series of cooperative arrangements with other government agencies, IKONOS imagery of other areas may become available in 2001.

A second NMFS Honolulu Laboratory proposal that was recently approved involves the use of ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) imagery. ASTER is an imaging instrument that is flying on Terra, a satellite launched in December 1999 as part of NASA's Earth Observing System (EOS). ASTER is the only high spatial resolution instrument on the Terra platform. Although the resolution from ASTER imagery may be too coarse to detect derelict nets, high-resolution IKONOS images could be used to develop a spectral library for derelict nets and this library used to determine if reflectance signatures of nets can be identified in the ASTER imagery. ASTER imagery will also be used to improve base maps, categorize and map shallow-water bottom types, and perhaps map and monitor coral reefs. One major advantage of the ASTER imagery is that it will be obtained for no charge and will provide summer and winter imagery for the next five years of the entire NWHI chain, as well as the other U.S. possessions in the Pacific.

A final source of imagery may be the AVIRIS (Airborne Visible InfraRed Imaging Spectrometer) imager. AVIRIS is a unique optical sensor that flies aboard a NASA ER-2 airplane at approximately 20 km above sea level, providing a ground resolution of 20 m.

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The main advantage of AVIRIS is that it is a true hyperspectral instrument that allows very precise spectral segregation, to possibly identify the reflectance or equivalent signatures of derelict fishing nets. The disadvantages include the relatively coarse resolution and the cost of the imagery for those other than co-principal investigators. Data from a series of flights over the NWHI in Spring 2000 may become available to NMFS researchers from the principal investigators.

Remote-sensing methods may prove effective at identifying and mapping derelict net accumulations. The success of the methods will depend on the ability to correctly classify the unique spectral signatures of the nets and to be able to distinguish the nets from their surroundings. Since proper classification depends on verification through in-situ field-work, precise field mapping is a key component to the success or failure of such initiatives.

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APPENDIX 1.

FISHERY RELATED RECOMMENDATIONS AND CONCLUSIONS FROM PREVIOUS MARINE DEBRIS CONFERENCES.

Workshop on the Fate and Impact of Marine Debris, 1984, Honolulu, Hawai'i (Shomura and Yoshida, 1985)

Conclusions and Recommendations

Studies should be undertaken to:

1. Determine the sources and distribution of debris, possibly through development of a sampling methodology.

2. Determine the fate of lost gear and debris once it is deposited in the marine environment.

3. Develop a means of identifying derelict gear through creation of a reference collection.

4. Obtain worldwide data on vessel disablement as a result of interactions with marine debris.

Additional efforts should be undertaken to:

1. Obtain data on gear problem in areas other than the North Pacific

2. Expand existing stranding networks for marine mammals, birds, and turtles, and incorporate examinations for evidence of interactions with debris.

North Pacific Rim Fishermen's Conference on Marine Debris, 1987, Kailua-Kona, Hawai'i (Alverson and June, 1988)

Identified research needs as follows:

1. Expansion of national and international studies of the density, distribution, and movement of marine debris in the world's oceans.

2. Examination of cost-effective systems to facilitate the identification, recovery, and return of lost fishing gear to port or owners.

3. Continuation and expansion of beach surveys to monitor trends in marine debris abundance and type. This is particularly important in the North Pacific, but warrants consideration in other ocean regions.

Report of the Interagency Task Force on Persistent Marine Debris, 1988: Booklet produced and published by the Alaska Sea Grant College Program under the direction of the NOAA, Office of the Chief Scientist (Alaska Sea Grant, 1988)

1. Federal agencies should continue to participate actively in international forums to reduce persistent marine debris.

2. The administration should support the NOAA Marine Entanglement Research Program by including it in the administration's fiscal year 1990 budget and for at least five years thereafter.

3. The topic of persistent marine debris should be included in the five-year Federal Plan for Ocean Pollution Research, Development, and Monitoring.

4. NOAA, the U.S. Fish and Wildlife Service, the Marine Mammal Commission and other agencies should expand research and monitoring activities to determine more precisely impacts of persistent marine debris on fish and wildlife populations, particularly endangered, threatened, and depleted species.

5. EPA, NOAA, U.S. Coast Guard, and other agencies should carry out research to determine contributions of land-based and vessel sources of plastic refuse to the overall problem, as well as ways to reduce plastic debris from all sources.

6. NOAA should work with fishermen and equipment manufacturers to develop pragmatic ways to improve ways to recover lost fishing traps and nets.

7. Beach Cleanup and Monitoring: Federal agencies should work cooperatively among themselves, as well as with state agencies, private industry, and environmental groups to remove marine debris from beaches and other parts of the marine environment. Federal agencies should encourage coordination with state and local authorities for conducting systematic monitoring of marine debris accumulation and impacts in order to assess compliance with regulations prohibiting disposal of plastics and controlling other solid waste discharges into U.S. waters.

8. Federal agencies that manage coastal properties should set up actions to remove persistent marine debris.

9. Federal agencies should support local volunteer beach cleanup efforts as well as the collection and interpretation of data on materials that the volunteers remove. Federal managers should encourage employees to participate in volunteer cleanups.

Second International Conference on Marine Debris, 1989, Honolulu, Hawai'i (Shomura and Godfrey, 1990)

General conclusion: "The recommendations from the 1984 FIMD workshop have not been fully met. Efforts to measure the sources and amounts of persistent debris have been greater in the North Pacific than in any other ocean area, but a full understanding of the dynamics of input, output, and circulation remains well in the future."

Recommendations:

1. Development of a set of standard methods for surveys of the amounts, types, and sources of marine debris.

2. Establishment of an international committee or organization to further collaborative research on the impacts of entanglement on living marine resources.

3. Design and implementation of baseline experiments to establish the lethal and sub-lethal impacts of persistent debris ingestion by sea turtles and seabirds.

4. Design and implementation of experiments to evaluate ghost fishing in gillnet and trap fisheries with high gear loss rates and developing mitigative measures as needed.

Third International Conference on Marine Debris, 1994, Miami, Florida (Faris and Hart, 1995; Coe and Rogers, 1997)

1. Focus on and publicize the problem of combined sewer overflows. Continue research on terrestrial sources of debris.

2. Rigorously investigate the sub-lethal impacts of debris ingestion among turtles and birds—how it creates a false sense of satiation, dilutes nutrients, impairs digestion, and affects reproductive capacity.

3. Research and implement mechanisms to reduce fishing gear loss. These could include technological changes in gear design or incentives to recover lost gear. Given the appropriate incentives, the collection of derelict gear may be feasible.

4. Investigate the fate of plastic and other debris after they break down into minute particles in the marine and littoral environment. Research their potential impact on marine organisms.

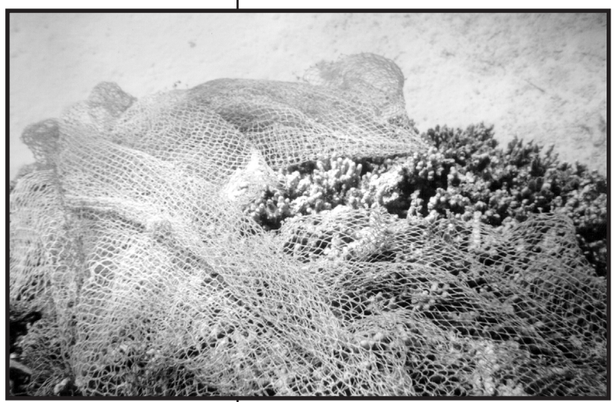
5. Investigate the scope and importance of organism transfers by marine debris, especially the introduction of invasive alien species that could disrupt native communities and ecosystem functions.

6. Investigate the amounts, accumulation rates and impacts of debris on the seafloor and the potential for large-scale impacts by smothering.

7. Monitor rates of entanglement and ingestion among selected species at specific sites. Collaborate with existing studies in certain regions. For instance, records of entanglement and ingestion in the Antarctic Treaty region are collated by the CCAMLR (Convention on the Conservation of Antarctic Marine Living Resources) Scheme of International Scientific Observation. Flagship species such as marine turtles and cetaceans can be used to promote field observations.

8. Establish an impact reporting system to promote and collate observations by beach users, fishermen, oceanographers, scuba divers, and others. Start by compiling past records.

9. Make efforts to recover lost fishing gear in areas where it is likely to be concentrated. Also, take steps to better evaluate the kinds and amounts of fish caught and the potential effectiveness of such work to clean up hazardous ghost fishing gear. Establish a system to record gear loss by commercial fishermen.



Carolyn Sramek (NOAA), courtesy of NMFS

EDUCATION AND OUTREACH APPROACHES TO REDUCE AT-SEA DISPOSAL OF FISHING GEAR

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INTRODUCTION

Marine debris pollution was brought to the public's attention in the early-1980s when research on this issue was consolidated and presented at the First International Conference on Marine Debris in 1984. This conference has been followed by almost twenty years of further study to determine the breadth and scope of the problem, the development of a myriad of educational and outreach programs to mitigate the effects, and the passage of key legislation to control at-sea solid waste disposal.

Education and outreach efforts have been viewed as an integral component of virtually all strategies to mitigate the effects of marine debris. Education programs are generally built around various motivational themes, with the ultimate goal of changing the disposal behavior of marine user groups. The importance of and the need for marine debris education has been upheld at international conferences and meetings throughout the years, including the 1984 International Workshop on the Fate and Impact of Marine Debris; subsequent International Conferences on Marine Debris (1989 and 1994); the 1988 North Pacific Rim Fishermen's Conference on Marine Debris; and in the U.S., the 1988 Oceans of Plastic Workshop; and the 1989 Interagency Task Force on Marine Debris.

In the United States, legislators also mandated that the U.S. National Oceanic and Atmospheric Administration (NOAA) and the U.S. Environmental Protection Agency (EPA) conduct a three-year public education program as part of MARPOL Annex V enacting legislation entitled the Marine Plastic Pollution Research and Control Act of 1987.

This paper reviews the recommendations made by previous international and U.S. domestic forums regarding educational needs to address the marine debris problem, briefly outlines the history of marine debris education and outreach efforts, and provides examples of successful educational approaches that have been used around the world. We have also attempted to lay the groundwork for this conference's working group on Education and Outreach by formulating several draft recommendations for future marine debris educational work.

A summary of recommendations that have been forthcoming from previous conferences and workshops on marine debris is given in Appendix A. The summary pertains to only those recommendations related to education and outreach on the marine debris issue.

RECOMMENDATIONS FROM PREVIOUS MARINE DEBRIS CONFERENCES AND WORKSHOPS

History of Marine Debris Education and Outreach Efforts

In 1973, The Tidy Britain Group, the United Kingdom's agency responsible for the prevention and control of litter, responded to the growing public concern over marine debris by establishing a Marine Litter Research Program (Dixon, 1990). As described by Dixon, 'the program's overall strategy has been to quantify the nature and scope of the problem in the coastal and oceanic waters of Western Europe, and to persuade governments, intergovernmental organizations, and the shipping industry of the need for remedial actions.' The program included a beach survey component as well as public awareness campaigns and other educational initiatives. One such initiative provided background expertise and knowledge in the development of a training package for ships' crews that was incorporated into the IMO Guidelines for the Implementation of Annex V of MARPOL 73/78 (Dixon, 1990).

In 1984, in a report prepared for the U.S. Marine Mammal Commission, the Environmental Defense Fund assessed U.S. and international authorities that may be applicable in studying and/or addressing the problem of lost or discarded fishing gear (EDF, 1984). Several of the report's recommendations regarding the fishing industry are listed below:

- Research into enhancing biodegradability and recycling of plastics pollutants should be a national priority.
- Sea Grant sponsored compilations of fishing hangs and bottom obstructions should be incorporated into the National Ocean Service's "Notice to Mariners" and reflected on official nautical charts.
- Sec. of Commerce should develop a gear inventory requirement that will aid the tracking of nets from original use to ultimate disposal.
- Observer reporting forms should be reviewed to determine whether they allow for adequate reporting of gear disposal by the observed vessel as well as sighting of lost, discarded or inadequately marked gear from other vessels.
- Observer reports should be reviewed to determine the extent of noncompliance with the prohibition against gear disposal at sea by foreign vessels.
- The regulations implementing fishery management plans should be amended to include provisions respecting the disposal of gear at sea and the reporting of abandoned gear.

In 1986, a study conducted by the Center for Marine Environmental Education (CEE), in cooperation with Centaur Associates, Inc., looked at the sources of marine debris in the Western North Atlantic and Gulf of Mexico, and characterized the nature of the threat to living marine resources posed by each debris type. The study identified manufacturers of the debris items, as well as the target audiences within each manufacturer and depositor group that might be susceptible to education programs designed to promote voluntary reduction of their contributions to the marine debris problem. Subsequently, educational materials were developed targeted for specific marine user groups which included: a series of four slide shows and taped scripts for commercial fishers in the North Atlantic, Mid-Atlantic, Southeast Atlantic, and Gulf of Mexico; a video and education packet for petroleum industry employees; and three print public service announcements and accompanying brochures for commercial fishers, merchant shippers, and plastic industry manufacturers and processors (Centaur Assoc. and CEE, 1986).

In 1987, CEE expanded the development of educational materials on the marine debris problem targeting additional marine user groups. The Society of the Plastics Industry (SPI) joined forces with CEE to inform marine user groups of the marine debris problem and the need for proper disposal of plastic. This awareness campaign included the production and dissemination of print public service announcements and accompanying brochures for recreational boaters and fishers, commercial fishers, merchant shippers, and plastic industry manufacturers and processors. CEE also produced a "Citizens Guide to Plastics in the Ocean," a primer on the marine debris issue and actions that can be taken to mitigate the problem.

In 1989, the National Oceanic and Atmospheric Administration, under contract with the Center for Environmental Education, established two Marine Debris Information Offices (MDIO) in the United States. The objective of these offices was to establish and maintain a center for distribution of information and materials to educate industries and the general public about the impacts of persistent marine debris, and their roles in its creation, removal, and proper disposal. These offices were operated by CEE from 1989 through 1996.

In 1989, funded by a Saltonstall-Kennedy grant from the National Marine Fisheries Service and conducted by the Center for Marine Conservation and Kearney/Centaur Division of A.T. Kearney, Inc., a study was designed to develop, test, and evaluate marine debris education for commercial fishers and recreational boaters as part of an effort to develop cost effective methods to comply with the prohibition of at-sea disposal of plastics and other wastes. The project was conducted at four sites: Bayou La Batre/Coden, Alabama; Martin County, Florida; Hampton, Virginia; and Taylor County, Florida (O'Hara and Wallace, 1990).

The main goals of this project were to: (1) assess the level of understanding of the marine debris problem among commercial fishers and recreational boaters, (2) inform these marine users about the marine debris problem, (3) increase awareness of and encourage compliance with federal regulations on at-sea dumping of plastics and other trash, and (4) evaluate the role of education in increasing awareness about the marine debris issue and in encouraging compliance with federal regulations.

Recommendations based on the experience of this project were to:

- Continue to evaluate marine debris education as a cost-effective means of encouraging compliance with the prohibition of at-sea disposal of plastics and other wastes.
- Test difference evaluation techniques such as case studies and more extensive surveys to assess marine debris education.
- Establish a two-tiered marine debris presentation strategy incorporating the "train-the-trainer" approach so that a sufficient number of volunteers/presenters could be educated about marine debris issues.
- Establish and maintain contact with the press and media to promote awareness about the problems of marine debris and the proactive steps being taken to manage this issue.

The list of marine debris educational materials and programs developed in the United States in the 1990s is extensive. A number of state environmental agencies, Sea Grant offices, non-profits, and aquaria developed excellent materials to educate the public on this issue. Several curricula were developed on the subject, including "Ripples" and "Splish Splash" for elementary students from North Carolina Sea Grant, "Turning the Tide on Trash" from the EPA (produced in both Spanish and English), and "Save Our Seas" produced by the California Coastal Commission and the Center for Marine Conservation. A number of resource materials were created for different marine user groups including boaters, recreational fishers, cruise line passengers, shipping companies, offshore oil and gas operations, and the fishing industry.

In Australia, education programs have been the main strategy used to reduce debris. A range of educational programs has been conducted at both the national and local level that target users of the marine environment. Educational materials developed for marine users include brochures, information leaflets, stickers, posters, and magazine articles. Clean Up Australia conducts annual coastal cleanups that also serve as public awareness programs and Greenpeace also conducts an Adopt-A-Beach Program, another important outreach tool. Other programs conducted throughout Australia include a project that distributes education video to commercial fishers (Jones, 1995).

Environmental groups, government agencies, and industry trade associations in a multitude of countries around the world have developed marine debris resource materials and education campaigns. These groups, such as the Hellenic Marine Environment Protection Association (HELMEPA) in Greece; Japan Environmental Action Network (JEAN) in Japan; FUDENA in Venezuela; the International Marinelife Alliance in Hong Kong; Philippines, Indonesia and many others, have all played an important role in combating the marine debris problem in their respective countries.

BEACH CLEANUP PROGRAMS SERVE AS IMPORTANT OUTREACH EVENTS

Beach cleanup campaigns have long been recognized as an important tool for raising public awareness of the marine debris problem. These highly visible events often attract media attention, which only helps to increase the visibility of this issue. Informal beach cleanup efforts have been conducted for decades and perhaps even centuries. The Aleut native peoples of the Pribilof Islands have been cleaning the Northern fur seal rookeries each spring for generations, removing debris they believed would impede the seal's recognition of traditional pupping grounds and their progress ashore (Bourdukofsky, 2000).

Only in the last several decades have citizen volunteers organized on a much larger scale to participate in beach cleanup events that range across several states or countries and often times includes a data collection exercise.

As early as 1973, the Tidy Britain Group in the U.K. established a Marine Litter Research Program. An important component of the program has been the establishment of data collection methods to assess marine debris on coastal beaches. The two main goals of the data collection effort were to: (1) develop standardized field survey techniques and analytical methods for the surveillance of marine litter, and (2) identify the major trends in

the composition, distribution, and origin of litter occurring in the coastal and oceanic waters of Western Europe (Dixon, 1990). Early analysis of data revealed that containers of all types including bottles, cartons, drums, etc. were common components of the overall total. Samples of the most frequently occurring types were recorded and a technical support network of packaging and product manufacturers was established to discover the wastes' geographic origins, contents, and dates of production. Analysis of the data collected from shoreline transects has enabled Tidy Britain to assess 'major trends in the composition, distributions, geographical origins, and persistence of litter in the surface waters of Western Europe' (Dixon, 1990).

Also in the early-1970s, Japan led efforts to clean not only beach areas but also the fishing grounds of coastal communities. Concern over the accumulation of debris such as bottles, cans, worn-out tires, plastic bags, and other plastic items on shorelines as well as on the sea floor prompted the government of Japan to launch a Cleanup Program. The Fisheries Agency developed a two-pronged approach, conducting educational programs for coastal communities and cleanup activities of the seashore and sea bottom. More information on this program is given below in the Education and Outreach Approach section A.2. (Yagi and Otsuka, 1990).

Judy Neilson with the Oregon Department of Natural Resources in the United States first conceived of the idea of holding a state-wide beach cleanup of Oregon's 350 miles of coastline in 1984. Ms. Neilson organized a task force, dividing the coast into fourteen zones and recruiting local residents to serve as "zone captains." Held in October in conjunction with Coastweek activities, the cleanup attracted 2,100 volunteers who collected over 26 tons of debris in just three hours. Volunteers filled out questionnaires to document the quantity of fishing gear, six-pack rings, polystyrene foam, plastic bags and bottles, rope, and strapping bands (Neilson, 1990).

Encouraged by her success, Ms. Neilson recruited environmental leaders in eight other states to join the Cleanup and went on to write the "Nuts and Bolts Guide to Organizing a Beach Cleanup," to help them organize their own efforts. By 1986 there were fourteen states participating, including an effort in Texas, led by the Center for Marine Conservation. The Cleanups have always been held during Coastweeks, a national celebration of our coasts.

Ms. Neilson's idea inspired the Center for Marine Conservation to organize coastal cleanups across the United States in both coastal and inland states. Starting in Texas in 1986 with 2,800 volunteers, the Cleanup has expanded to include inland lakes, rivers, and streams, as well as underwater sites. Today, the International Coastal Cleanup (ICC) is the planet's largest volunteer effort on behalf of the marine environment. Cumulatively, more than three million people in over 100 countries have participated in the cleanup since it became an international event in 1989. Volunteers use standardized data collection cards, developed by CMC, to record more than eighty specific debris items in eight categories: plastic, foamed plastic, glass, rubber, metal, wood, and cloth. The data analysis is returned when completed to each state and country partner for their use in formulating education and public awareness campaigns in their locales.

SOURCES OF MARINE DEBRIS

The data recorded by volunteers can often times be analyzed to identify the sources of beach debris collected during a cleanup. Marine debris researchers traditionally classify debris source as either land- or ocean/waterway-based, depending on where it enters the water. Other factors such as ocean current patterns, climate and tides, and proximity to urban centers, industrial and recreational areas, shipping lanes, and commercial fishing grounds influence the type and amount of debris that is found in open ocean areas or collected along our beaches and waterways—including underwater areas.

Land-based debris blows, washes, or is discharged into the water from land areas. Sources include: recreational beach-goers and fishers; materials manufacturers, processors and transporters; shore-based solid waste disposal and processing facilities; sewage treatment and combined sewer overflows; inappropriate or illegal dumping; and littering.

Ocean/waterway-based debris is generated by people who discard debris at sea and in inland waterways. Identified contributors are: recreational boats; commercial fishing vessels; cruise ships; merchant, military, and research vessels; and offshore petroleum platforms and associated supply vessels. Debris ends up in the water due to accidental loss or system failure; historical waste management practices; or illegal disposal and indiscriminant littering.

Commercial fishing activities introduce marine debris into the ocean and waterways through intentional disposal by discarding trash overboard and by not retrieving excess gear and through unintentional loss when gear wears out and is lost while deployed or the equipment operator makes a mistake and the gear breaks loose. Commercial fishing is associated with debris items such as nets, salt bags (large, reinforced plastic bags used by commercial fishermen to preserve or separate their catch), bait boxes and bags, fish baskets or totes, fish and lobster tags, and gill-net or trawl floats (Wallace, 1995).

STAKEHOLDERS RELATED TO COMMERCIAL FISHING AND DERELICT GEAR MARINE DEBRIS ISSUES

For educational purposes, there are several audiences related to commercial fishing and derelict gear issues. The core of this group consists of fishers ranging from single, subsistence individuals who may or may not own their own boats to crews on large trawlers. Business and industry associated with equipment and boat manufacturing and marketing are also part of this audience as they are responsible for the production and sales of the materials used by fishers. Individuals who are part of the fish processing industry including marketing are also part of this group. And last, but not least, are the governmental regulatory and resource management entities, which are needed to complete the entire scope of this issue.

EDUCATION AND OUTREACH APPROACHES

For discussion purposes the following approaches are organized into two categories: (1) education and outreach approaches directly involving fishers, the primary stakeholders, and (2) approaches that target other stakeholders, for example, non-fishing members of coastal fishing communities, ports and reception facilities, and gear manufacturers.

A. Education and Outreach to Fishers as Primary Stakeholders

When dealing with the problem of marine debris, the issues of concern and/or interest to the fishing industry as a whole and to individual stakeholders within fisheries revolve around several topics:

- Laws and regulations governing at-sea disposal.
- Economic impacts from direct costs such as damage to or disabling of vessels from entanglement in lost gear.
- Safety issues related to vessel disablement due to involvement with debris.
- Hidden costs such as:
    1. Fines and related penalties.
    2. The opportunity cost from downtime while a vessel is disabled.
    3. Loss of valuable time while removing debris from nets.
    4. Loss of revenue from "ghost fishing."
- Degradation of essential fish habitat related to underwater marine debris accumulation.
- Deposition of marine debris on beaches.
- Impacts to wildlife species (especially those revered by their cultures).

In 1989, in a survey conducted in four coastal fishing communities in the United States by CMC, under contract to A. T. Kearney Inc., and as part of a project funded by the National Marine Fisheries Service, more than 95% of fishers surveyed had seen plastic trash floating in the water. Over 45% had had vessel propellers caught in plastic, over 30% had gear caught or fouled by debris, and almost 40% had vessel cooling intake systems clogged by debris. About 94% of those surveyed viewed plastic debris in waterways as a safety hazard for mariners, a source of mortality for marine animals, and a source of beach litter (Wallace, 1990).

During this same survey, commercial fishers were asked which of seven techniques were the best ways to encourage fishers to retain debris on their vessels for disposal ashore. Close to 60% cited fines and penalties as effective, followed closely (~55%) by the availability of dockside disposal facilities. Other techniques noted as effective were posters (~39%), word of mouth (~35%), brochures (~32%), and magazine and newspaper articles (~31%). Presentations were considered the least effective tool and were noted by only ~17% of those surveyed. Respondents to the survey were also given the opportunity to make suggestions on outreach approaches. Among the suggestions were reminders on the marine radio channel, incorporation of information on proper garbage disposal into the licensing procedure, and the use of advertisements and stickers (Wallace, 1990).

Around the world, the range of stakeholders in the fishing industry is wide, running from owners and operators of large factory trawlers down to members of small subsistence artesnal fisheries. Different approaches for education and outreach need to be devised not only for different size industries but also for different cultures. Various approaches that have been used with commercial fisheries are listed below. For each approach, several examples are given.

1. ***Industry Programs*** – industry education and mitigation programs devised by and for the fishing industry.

Fishing industry trade associations in the **United States** often provide orientation sessions for new employees that review the MARPOL regulations and a company's waste disposal policies. Companies may make compliance a condition of employment, and employee contracts will sometimes stipulate that the employee agrees to adhere to all relevant laws and regulations, such as MARPOL and MPPRCA (Minton, 2000). According to Mark Minton with the National Marine Fisheries Service, 'most vessels, whether formally or informally, provide new crew members an orientation and overview to the policies and procedures they are expected to follow, including waste disposal.'

Currently, in **Kodiak and Dutch Harbor, Alaska, U.S.**, the fishing industry is working closely with port authorities to ensure that vessel wastes and worn and damaged nets are disposed of properly. Collectively, approximately 800 tons of nets are landfilled each year in these communities. In Dutch Harbor many of the nets are stockpiled and removed once a year on barges, which transport them to recycling centers (Minton, 2000). In Kodiak, many of the nets are collected from the port by individuals in the community, who re-use them for erosion control, landscaping, and pest control for gardens. The Kodiak Chamber of Commerce is also studying the feasibility of burning the worn nets for power generation. Kodiak also has a program to recycle and re-use motor oil that reportedly has saved approximately $100,000 (U.S.) annually on waste oil disposal (Minton, 2000).

In **Nova Scotia, Canada** the Maritime Fishermen's Union ran a successful program in the early-1990s, supported by Environment Canada, to educate fishing communities about the problem of marine debris, encouraging fishers to bring their waste back to port and also encouraging port managers to provide facilities (i.e. barrels and dumpsters) for disposal of wastes and used nets (Topping, Morantz, and Lang, 1997). Similarly, the Nova Scotia Dragger Fishermen's Association disseminated educational materials to their members to improve compliance with MARPOL regulations (CMC, 1990).

In **Oakland, California, U.S.** the Vietnamese Fishing Association has played an active role in educating their members about the marine debris problem and MARPOL regulations. They translated a MARPOL Annex V placard outlining disposal restrictions into Vietnamese for their own and other Vietnamese fishing communities (CMC, 1990).

In 1987 at the North Pacific Rim Fishermen's Conference on Marine Debris, a **Japanese** representative from the Japan Fisheries Association stated that 'each Japanese industry association responsible for its respective fishery has been educating its member fishermen on the importance and urgency for setting up measures to control marine debris under the guidance of the Japanese government' (Nakamura, 1988). A recycling program was set up to recycle nets used in the driftnet fisheries, processing the recycled plastic into bobbins, plastic dishes, panel materials or other construction materials, and other containers. One recycling company processed approximately 1,200 tons of worn nets per year (Nakamura, 1988).

The Highliners Association, based in **Seattle, Washington, U.S.** (a member trade association of fishermen, vessel owners, operators, and processors involved in fishing activities off the contiguous Pacific Coast states and Alaska), was one of the first industry groups to initiate programs to address the marine debris problem. In July 1986, in conjunction with Oregon Sea Grant and NMFS, the Highliners organized a workshop in Newport, Oregon for the trawl fishing industry, to raise awareness of the magnitude of the debris problem and look for workable solutions. Following this meeting, they assisted in the design and distribution of marine debris posters to West Coast commercial fishermen's groups, port authorities, recreational boaters, and others.

In 1988, as a result of a recommendation from the Pacific Rim Fishermen's Conference on Marine Debris, the Highliners Association developed a plaque entitled "Fishermen's Pledge for A Clean Ocean." The plaque was designed to remind captains and crew of fishing vessels of their responsibility to maintain a clean ocean environment and includes a pledge to return all discarded fishing gear and other plastics to port. It also encourages fishers to make every effort to prevent accidental loss of gear, and to make an effort to collect other vessels derelict gear when encountered at sea. The Highliners Association had great success in distributing this plaque to numerous fishing fleets for display in prominent locations such as wheelhouses or galleys (Uri, 1988).

2. ***Government Programs*** – federal, state, and local government initiated programs to educate the fishing industry and mediate the effects of discarded gear and other debris.

In 1999, the county government of the **Penghu Islands**, a 64 island archipelago off the west coast of **Taiwan**, spent $20,000,000 NT$ (~$600,000 U.S.) to buy back trammel nets (gillnets with three layers of nets with different size mesh) from local fishers and banned the future use of this type of gear. During this buy back program, about 640 km of trammel netting was purchased. The county government also commissioned a local SCUBA divers' association to investigate and record locations where substantial discarded trammel nets exist. After twenty-one locations were found, a plan was formulated to remove over 10 km of gear in a two-month period using divers operating off of five ships. Local citizens were also encouraged to report locations of discarded gear to facilitate cleanups. In the first ten minutes of the first day of cleanup (June 2000), more than 100 m of nets with fresh and decomposing fish were removed. The county government has vowed to continue the program until the local waters are free of discarded trammel nets. According to Dr. John Wang, scientific advisor to Kuroshio Ocean Education Foundation, who provided this report, this is a positive first step in Taiwan and should be a model for fisheries and other counties of Taiwan to follow (Wang, 2000).

In the 1990s, steps were taken by the **Australian** government to increase compliance with MARPOL regulations within the Australian Fishing Zone (AFZ), the world's third largest fishing zone. Working with Japanese officials, the government provided information sheets to Japanese vessels in Japanese, that spelled out the requirements of MARPOL. Discussions with Japanese authorities and industry officials on the benefits of using plastic-free bait boxes were also held. Subsequently, an observer reported that 50% of bait boxes used on one vessel were strap-free (Jones, 1995).

The **Canadian** government has also been active in outreach to their commercial fishing fleets. In the early-1990s, Canadian Department of Fisheries and Oceans developed and produced a bi-lingual brochure on the problem of marine debris for distribution to Canadian fleets (CMC, 1992). Canada's Fisheries and Oceans Communications Branch in Halifax, Nova Scotia distributed marine debris posters to over 400 ports and marinas in 1990 (CMC, 1990) and Environment Canada provided funding for marine debris educational programs to fishers in the early to mid-1990s (Jones, 1995).

As early as 1973, the Fisheries Agency of **Japan** initiated a program to recover its deteriorating fishing grounds. The amount of marine debris accumulated in the coastal areas of Japan had been shown to be an obstruction to the fisheries operating in these waters, causing habitat destruction of key commercial species and interfering with fishing operations. The Fisheries Agency's two-part program contained an educational aspect and a cleanup aspect. The educational aspect involved alerting regional residents, including fishermen, of the need to preserve the environment through radio and television broadcasts, newspaper articles, lectures, public ads, posters, leaflets, and calendars.

The cleanup aspect involved using trawl vessels to remove accumulated debris on the sea floor, cleanups of the rocky bottom using divers, removal of floating debris using dip nets, and manual cleanups of beaches as well as inland rivers, lakes, and streams. Although the cleanup program was initiated under the leadership of the government, programs were taken over willingly by local residents as years passed. Interest has grown as the educational programs have continued and some communities have formulated their own new initiatives such as the establishment of "Fishing Ground Preservation Month" to promote stewardship of their coastal environment (Yagi and Otsuka, 1990).

Through the Marine Environmental Protection arm of the **United States** Coast Guard (USCG), the "Sea Partners" Campaign was created to support environmental education and outreach program activities. Sea Partner programs focus on working to develop community awareness of maritime pollution issues and to improve compliance with marine environmental protection laws and regulations. As part of the Sea Partner's program, regional Marine Safety Offices (MSOs) Coast Guard staff and Auxiliary members conduct pollution prevention programming relating to the effects of: marine debris, waste, chemicals, and oil on the environment; the application of marine environmental protection laws and regulations; and the actions that groups and individuals can take to protect the marine environment.

One of the ways that the Sea Partners Campaign reaches the commercial fishing industry is through attendance at industry-related trade conferences, including Fish Expos, where they distribute information on safety and environmental issues. Some MSOs conduct voluntary inspections on fishing vessels where they also provide information on environmental practices and strategies.

3. ***Organization Education Programs*** – developed by NGOs and other groups in conjunction with, and in support of, the fishing industry's educational programs.

From 1988–1996, the Center for Marine Conservation (CMC), under contract with the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, established two Marine Debris Information Offices (MDIO) in the **United States**. They were the Atlantic Coast and the Gulf of Mexico MDIO located in Washington D.C. and the Pacific Coast MDIO located in San Francisco, California. The objective of these Offices was to establish and maintain a center for distribution of information and materials to educate industries and the general public about the impacts of persistent marine debris, and their roles in its creation, removal and proper disposal. As part of this function, CMC developed extensive informational packets, which were used to address a variety of marine debris issues and respond to stakeholders associated with marine environment. Information to promote marine debris prevention activities for commercial fishers was compiled and distributed at major trade shows, conferences, regional fisheries management council meetings, and a host of other public venues.

A **United States** government supported program that supports efforts to educate the fishing community is the National Sea Grant College Program. Sea Grant is a partnership between U.S. universities and the National Oceanic and Atmospheric Administration (NOAA) that began in 1966, when the U.S. Congress passed the National Sea Grant College Program Act. Today, of the twenty-nine Sea Grant Colleges, many have outreach or education programs that aid the commercial fishing industry. Examples of marine debris programming conducted by Sea Grant Offices include:

- Maine/New Hampshire Sea Grant—addresses issues associated with fishing cooperatives, marine mammal/fishing gear interactions, alternative species/bycatch, and fisheries management. Maine Sea Grant produced an important resource for marine users that spelled out the requirements of MARPOL Annex V.

- Washington Sea Grant—developed an innovative program in the late-1980s in the Port of Bellingham to establish a net recycling facility; produced a series of pamphlets combating the marine debris problem including one entitled "Marine Debris: How Commercial Fishermen Can Help Solve a Growing Problem."

- Oregon Sea Grant—has conducted an extensive marine debris campaign since the late-1980s. A program was developed for the Port of Newport called "Don't Teach Your Trash to Swim" where boaters were encouraged to bring debris to shore for disposal; it also focused on changing fishing gear to prevent ghost fishing if the gear was lost.

- Hawai'i Sea Grant—conducts an extensive marine debris prevention campaign for recreational and commercial fishers, which includes a local program for derelict net and gear retrieval (Marine Bounty program).

- Alaska Sea Grant—sponsored a workshop in 1988 to discuss incentives for fishers to bring back old gear and retrieve lost gear.

4. ***Incentive Programs***

In 1997 the Center for Marine Conservation developed a community-based program to

address marine debris sources through education and the development of improved waste management practices. The Model Communities program provides communities with tools to encourage changes in waste disposal habits so as to reduce debris entering waterways and works to transfer and replicate management approaches and educational materials to other communities with similar marine pollution concerns. One such program is being conducted in the **United States in Hawai'i** and includes an incentive program for local coastal fishers called the "Marine Bounty Program." This program was developed and piloted in Kaneohe Bay, on Oahu, where recreational and commercial fishers were awarded points for reporting the location of abandoned nets found while fishing. Points were redeemed for fishing products and other prizes donated by local retailers. Arrangements were made with a local fisher (Randy Cates of Safety Boats Hawai'i) by the University of Hawai'i Sea Grant office to have the nets retrieved and disposed of in the local landfill. The program continues with over three tons of recovered nets and gear to date. Plans are underway to expand this effort to other areas of Oahu tying this to a net monitoring program being implemented in Hawai'i through the Coastal Zone Management Program and the Department of Land and Natural Resources.

Other incentive programs have been conducted in the **U.S. in Florida and Louisiana** using recreational fishing rodeos or tournaments as the venue. While not targeting traditional commercial fishing, individuals involved in coastal commercial sport fishing ventures are oftentimes interested in or participants of local sport fishing tournaments and may benefit from this type of outreach activity. Typically, these incentive programs are set up in a similar fashion and may carry a slogan such as "Stow it, Don't Throw It." When participants register for the rodeo or tournament, they are given a garbage bag and the rules of the "contest" are explained. Entrants are asked to retain their garbage onboard and often are also asked to retrieve floating debris they encounter during the day. For those entrants who return to shore a bag filled with their day's garbage they are given a ticket for a special drawing for valuable prizes. Some contests also give extra prizes for entrants who return two bags of trash—one containing separated recyclables (Laska, 1990; CMC).

5. Observer Programs

Informal education of fishers related to MARPOL regulations is conducted in **Australia** by observers on Japanese vessels as part of the Australian Fishing Zone (AFZ) Observer Programme. A study of observer reports for 1992-93 indicates that in 1992, 57% of the vessels carrying observers complied with MARPOL; in 1993 compliance was 46%. One-third did not comply, and the remainder was either doubtful or complied only after being advised of regulations by the observer. The observers' reports noted that the reasons for non-compliance included a lack of knowledge of MARPOL regulations, the attitude of the Captain and/or the crew, and lack of facilities for proper disposal due either to a lack of incinerators on board the vessel or inadequate facilities at the port (Jones, 1995).

While the study showed that informal education of fishing crews by observers was only sometimes successful in changing disposal practices, it was concluded that continued collection of observer data would be helpful in monitoring the situation and useful for planning future actions (Jones, 1995).

A similar study was conducted in **Canada** by the Fisheries Observer Program, operated by the Department of Fisheries and Oceans, in 1990–91. Observers on both Canadian and foreign fishing vessels operating in the Canadian Exclusive Economic Zone in the Atlantic, collected data on the vessels' waste disposal methods and the types of waste disposed, including the types of plastics. A "marine plastic debris occurrence report form" provided standardized categories for four basic disposal methods and eighteen types of waste and was used to collect data on 739 trips during the two-year study. Waste was discharged into the ocean, either directly over the side or through a galley chute during 76% of all trips; it was offloaded at port during 26% of all trips and incinerated on 14% of all trips (vessels used more than one disposal method during some trips) (Topping, Morantz, Lang, 1997).

Over the course of the study, the disposal practices of Canadian fishing vessels improved, showing a decrease from 96% of trips discharging waste into the ocean during the first five months of the study to 57% discharging at sea during the last five months. Foreign vessels discharge rates at sea remained fairly constant during the study (72% of trips) period but their rate of incineration also remained constant (46% of trips). The study concluded that the data 'suggest that the effect of the observer's presence was minimal on foreign vessels but almost certainly is responsible for the trend toward port discharge by the observed Canadian vessels.' Rather than attributing the decline to educational efforts by the observers themselves, the study credits educational efforts of the industry itself in concert with the Canadian government (see section 1 above). The study speculated that the continued practice of at sea disposal by over 50% of trips might be due to 'the limited availability of waste reception facilities and the disposal fees charged by ports.'

Interestingly, the study concluded that one reason foreign vessels favored incineration was energy recovery—waste incinerators also provided heating for the crew. Another waste reduction practice, reusing of plastic materials, especially containers and nets, was observed to be practiced by some foreign crews. Vessels from the former Soviet Union had the lowest estimated disposal frequencies for most waste types (Topping, Morantz, Lang, 1997).

While the Canadian study did not include a formal educational component (by observers) both studies show this as a potential means of outreach to commercial vessel crews and, more importantly, as a viable means to measure the success of a targeted education program to a specific fishery by assessing the amount of debris discarded before and then after such a program is implemented.

B. Education and Outreach to Other Groups as Secondary Stakeholders

This part of the discussion will focus on education and outreach approaches that target other stakeholders, for example, non-fishing members of coastal fishing communities, ports and reception facilities, and gear manufacturers. All of these groups may have a direct or indirect effect on the disposal practices and compliance rate achieved by various fisheries. For example, without adequate disposal facilities at ports of call, compliance with MARPOL becomes extremely difficult. Gear manufacturers and suppliers can contribute to

a higher level of compliance by changing technology to meet the fishing industries needs. Public awareness in coastal fishing communities generated by events such as beach cleanups may have an indirect effect on the members of fisheries associated with these communities.

6.Outreach Efforts Directed at Gear Manufacturers and Suppliers

In 1990 in **Tasmania, Australia** an initiative was begun to develop a plastic-free bait box containing no plastic liner or plastic straps. This represents one of the first successful attempts to modify fishing gear in an effort to reduce plastic debris. The plastic-free bait box was a result of a cooperative effort by the Tasmanian Parks and Wildlife Service, a bulk supplier of fishing bait, and a container manufacturing company. The box, after some refinements, is now also made by other manufacturers and is reported to be cheaper than the strapped bait box (Jones, 1995).

In the **Gulf of Mexico** region of the **United States** beach cleanup volunteers were repeatedly retrieving large, durable plastic bags with the Morton Salt name and logo prominently displayed. These distinctive blue bags held a salt product used primarily by the shrimp fishing industry in the Gulf to sort their catch on board. When Morton was approached by the Center for Marine Conservation and asked to help in rectifying the problem, they readily agreed. They test-marketed a reinforced paper bag but this did not prove durable enough to stand up to weather and sea conditions. Morton then agreed to put the environmental slogan "Stow It, Don't Throw It—Don't be a Litter Boat!" on their bags to promote proper disposal.

In the mid-1990s an environmental group in the **Hiroshima** area of **Japan** began working with local fishing cooperatives, port authorities, and government agencies to address the problem of polystyrene pollution of beaches. It was believed that the abundance of this material on the area's beaches could be traced to local oyster farming companies who use polystyrene foam floats for oyster rafts. Cleanups held by Cleanup Kansai Office, a regional member organization of Japan Environmental Action Network (JEAN), as early as 1992 have shown polystyrene pieces to be one of the most prevalent types of beach debris in the region. In the fall 1999 cleanups of three sites along Hiroshima's coastline, styrene foam pieces accounted for 60% of all trash items, and in two of these sites oyster-farming piping represented 17% of the total (Ohkura, 2000).

Through Cleanup Kansai Office's efforts, Molton, the manufacturer of the oyster raft floats, has developed and begun marketing a hard resin float that does not break apart and therefore poses less of a risk to marine life. Cleanup Kansai distributed the results of their beach cleanup data and information on the "eco-floats" to local supermarkets in January of this year. As a result, some local shops have started buying oysters produced from farms using the new floats, on a preferential basis. Furthermore, the company who developed the hard resin float has begun to apply this product to the gunwale protection material of vessels, replacing polystyrene material. This may help to further reduce the styrene foam trash on Japan's beaches.

Cleanup Kansai has worked out an agreement with Miyajim Fishing Cooperatives to return pipes found and collected at beach cleanups for reuse in oyster farming. The

plastic pipes, used to hang oysters on shelves, have been washing ashore on beaches around Hiroshima and other Seto-inland Sea coastlines (Ohkura, 2000).

7.Outreach Efforts Directed at Ports and Reception Facilities

Between February 1991 and June 1992, in four port areas in the **U.S. Pacific Northwest** region (Bellingham, Seattle and Anacortes, Washington and Cordova, Alaska), a gill net recycling program was conducted by the Pacific States Marine Fisheries Commission. During the sixteen-month run of this program, 47,000 pounds of old, nylon netting was collected at these sites. In this Pacific Region experiment, the baled nets were stored, marketed, and sold to a plastics broker. The nets were then recycled into bicycle seats in Taiwan. This was the first net recycling program attempted in the United States and provided many lessons for those wishing to explore the feasibility of this type of program. The success of net recycling in other communities depends on the quantities of old netting available, their market value, and the ability to manage the collection and handling systems. This study showed that gill net recycling was economically viable for the three ports in Washington. The operating costs in Alaska related to shipping were high resulting in costs to the port for transporting the nets. The success of net recycling in Alaska was dependent upon the availability of storage space for the nets until there was a sufficient volume of product that could be directly marketed to the end users bypassing the recycling brokers in Washington (Recht, 1995).

The Port of **Newport, Oregon, U.S.**, was the test site for the Marine Refuse Disposal Project from January 1987 through March 1988. This project focused on the return of refuse to the port through education of port users and to make available the facilities required to receive this refuse. The port increased the number of receptacles available for dumping and recycling, made them easily accessible, and worked with the port users to make this program a success. Public education played a large part as well, making this a community-wide effort. At the close of the project, 80% of the local fishers were voluntarily returning their refuse to the port, and encouraged others to do the same (Recht, 1988).

8.Outreach Efforts within Coastal Fishing Communities

Commercial fishing associations in the **United States** and **Canada** have been actively engaged in marine debris public awareness programs within their communities. The Virginia Waterman's Association developed their own sticker to distribute to fishermen and boaters, through local marinas, reading "PLEASE, Don't throw it, stow it!" In Alaska, the Bristol Bay Driftnetter's Association in the early-90s organized a MAPROL May Day event with a "Give a Hoot—Don't Pollute" message and distributed MARPOL placards to vessels in the area. The Maritime Fishermen's Union of Nova Scotia distributed marine debris brochures as part of their educational efforts to teach their communities about the marine debris problem. Their program also involved conducting a poster contest for elementary children. The Nova Scotia Dragger Fishermen's Association conducted a public school education campaign, visiting elementary schools in Shelburne School District to talk to close to 2,000 students about the marine debris problem. They distributed information packets, videos, and slide shows to teachers and posters, brochures, and activity sheets to the children (CMC, 1990).

In **Kosrae and Pohnpei, Micronesia** fishing debris is often found in reef areas, primarily consisting of monofilament line and longline fishing gear, as well as buoys and other associated gear. In Kosrae, the local resorts and civic organizations are involved in public awareness campaigns that are tied to beach cleanup events and general litter control. Marine debris education programs are continued year round in the schools as all the schools are located along coastal beaches, making informal beach cleanups and cataloging of debris possible as part of the curricula. Local women's groups, church groups, and other civic organizations have made litter prevention one of their focuses for community activism. Interestingly, it has been reported that due to Kosrae's location in an equatorial region, the strong sun breaks down plastic in a very short amount of time—reported to be no more than six months for many plastic items such as tarps (Edward and Adams, 2000).

Beaches debris found in coastal areas of the **Republic of Kiribati** often includes debris from both local and offshore fisheries. Floats and trawl gear, empty drums, as well as discarded gill nets are not uncommon. The Ministry of Environment and Social Development has begun a public awareness campaign that includes education via radio, organizing of coastal cleanups, and an annual program related to waste management control. Because of lack of space for landfilling waste, minimization of waste and programs such as composting have become increasingly important (Pulefou, 2000).

In **Hualien County**, on the east coast of **Taiwan**, Mr. Hung-Chi Liao, the director of the Kuroshio Ocean Education Foundation (KOEF) who is also a retired fisherman, guides monthly beach walks for the public to show and describe the beauty of and the conservation problems with Taiwan's marine ecosystem. The problems with discarded fishing gear and the types of fishing practices are described to participants, many of whom are professional educators who will, it is hoped, pass along this information to their students. This educational activity began about two years ago and is one of KOEF's main educational activities. KOEF is working to infuse into Taiwan's educational curricula, some instruction in marine conservation with development of workbooks, activity books, and slide presentations (Wang, 2000).

In **St. Paul Island of the Pribilof Islands of Alaska, U.S.**, the Aleut community has been involved in conducting an annual island-wide spring cleanup for generations. One of the island's most important natural resources is the seal rookeries, where approximately 70% of the world's population of Northern fur seals comes ashore every summer. Over the past four years a team of dedicated Aleut youth have been conducting a summer long disentanglement program—surveying the coastline on a daily basis looking for entangled seals, and, using long poles and a holding device, removing deadly nets and strapping bands from the necks of entangled seals. The "Disentanglement Team" has become highly proficient in the process of disentangling fur seals and has plans to share their knowledge with other high school students in other areas of the Bering Sea and throughout the Pacific Rim (Bourdukofsky, 2000).

In a project conducted in the United States by A. T. Kearney, Inc. in 1989 to devise a marine debris education plan for the shipping industry; a strong focus was placed on developing case studies of how this industry was dealing with new disposal laws and regulations. This was done through interviews with key contacts within industry and a review of documents provided by these contacts. The case studies provided examples of positive actions different companies were taking to change the way they handle plastics and garbage disposal and demonstrate the range of techniques that companies were using to comply with MARPOL Annex V. They also identified some of the problems encountered and how these were addressed and overcome (Wallace, 1990).

While recognizing that this project focused on an entirely different industry, this approach could also be successfully used with the commercial fishing industry—an industry that presents many of the same challenges to effective education due to its diversity. It is widely recognized that because of this diversity different education approaches are needed, and associated with that, as stated by A.T. Kearney, 'no one method of compliance with MARPOL Annex V will work for all vessels because of differences in such things as size, routes, cargo, and owners.' The case studies approach presents an effective way to document the success stories of various types of fisheries and can successfully address problems associated with vessel size and type, gear type, voyage length, and other factors that play a role in determining a workable waste management strategy. The case studies method also promotes a positive approach and involves industry directly in problem solving. This approach may be a better tool to use in reaching a goal of compliance than a more negatively focused education approach that identifies the fishing industry as a major source of debris and tries to convince them that their practices are causing problems. Various methods of disseminating these case study "success stories" may include distribution of information through fishing industry trade associations and membership organizations, seminar and workshop presentations at international fora, trade shows, publication in trade journals, and any other forum where industry representatives would have the opportunity to network and share information.

The positive approach is also supported by social scientists as the educational philosophy of choice. Laska (1990) states 'messages should be structured to enhance the self-image of the mariner as someone who conforms to environmentally sound behavior voluntarily rather than seeking conformity imposed by an external control. When external control is the only means used to persuade, the desired behavior will stop as soon as the external control is stopped. Also, the educational process should encourage the reinforcement of the message through group dynamics. The desire to conform to group norms and the power of group pressure to accomplish conformity should not be overlooked, for they are very powerful tools that can be employed to support implementation.'

In a related argument, there are differing views on an outreach approach outlined in section A above, namely, incentive programs involving a reward system for retrieval and proper disposal of worn gear. While incentive programs appear on the surface to be an effective tool for raising awareness of the marine debris problem, experts who believe they do little to change long-term behavior patterns have criticized them. Laska, in her study of the attitudinal basis of marine littering, cited a behavior modification theory related to

self-perception that can be successfully applied to changing littering behavior. The theory proposes that a change in behavior will occur once an individual has changed the perception of him or herself (self-image) as capable of a new behavior. Laska states that 'based on this theory, educational programs which encourage refuse disposal by giving prizes would not be expected to work over the long run because individuals do not have to change their self-image. The motivation to dispose correctly remains external to them, i.e., a prize given by someone else.'

However, there are those with a differing view of incentive programs. The U.S. Congress has demonstrated a preference for incentive-based policies based in part by its successes such as the Clean Air and Water Acts, which make extensive use of tradable pollution rights (Sutinen, 1997). Some believe the success of incentive programs is based in good evidence and is founded on sound economic theory. According to Sutinen, 'in almost any group of individuals subject to regulation there is often a core subgroup (usually small) of chronic, flagrant violators. Chronic, flagrant violators tend to be motivated only by the direct tangible consequences of their actions. Moral obligation and social influence have little or no effect on their behavior. Only changing the economic incentives… can control the amount of marine debris contributed by this subgroup.'

While disagreement exists between these two camps, it would appear that the long-term effectiveness of incentive programs needs to be thoroughly assessed, before initiating widespread adoption of this method of waste control.

Another important factor that needs to be considered in developing any program that has the goal of increasing compliance with anti-dumping regulations, is the attitude of modern society to convenience. Experts theorize that proper disposal of trash items is an inconvenience to an individual if a receptacle for the waste is not in the immediate vicinity (Laska, 1990). Laska states that 'the inconvenience is defined by the length of time the individual may have to maintain the item which no longer has utility within his or her personal domain—often extended if out at sea—and by the fact that it is occupying part of a very limited space—fishing boat, oil rig, freighter, camper.' Laska recommends that studies be conducted to 'determine the most convenient refuse disposal configuration at beaches, boat launches, marinas, and harbors.' The issue of convenient reception facilities, and more importantly, of adequate facilities, is essential to any waste management regime.

UNRESOLVED ISSUES AND CONSIDERATIONS

The following points have been identified as issues and considerations that need to be taken into account regarding the development of a comprehensive strategy for outreach to the commercial fishing industry:

1. There is currently a deficiency of educational programs and/or materials, which target the fishing industry, upon which to model new programs.
2. There is a lack of clear understanding of cultural factors, and motivational factors.
3. The range of stakeholders in the fishing industry runs from owners and operators of large factory trawlers to members of small subsistence artesnal fisheries. Different approaches for education and outreach need to be devised for different size industries.
4. The issue of whether education and outreach programs are highly effective in motivating changes in behavior is not yet conclusive; in addition, there has been no assessment of various types of outreach approaches to determine which are most effective.
5. The technology sector's interest in developing alternatives to present technology is unclear.
6. Is there a lack of education and participation by government, regulators, and resource managers to take regulatory action? This needs to be assessed.

OPPORTUNITIES FOR IMPROVEMENT AND ACTIONS NEEDED

The following points represent just a few of the opportunities and actions that are needed to begin to implement a region-wide outreach and education campaign for the commercial fishing industry.

1. Need for regional commitment to tackle the issue of the derelict gear issue, and the willingness to incorporate education as an important tool.
2. Need to be able to identify, communicate, and work with local agencies and organizations to support outreach efforts and develop programs.
3. Funding sources need to be identified for outreach and education programs.
4. Government and resource managers need to commit to both outreach programming and enforcement regimes.
5. Strong need for development of information sharing mechanisms and building of networks to disseminate educational models that have proven effectiveness.
6. Need to develop flexible models of outreach (two-pronged approach):
   - models that are readily adapted to local cultures and conditions (for coastal fisheries), and
   - models that are targeted at large pelagic fleets and commercial ventures.
7. New avenues of outreach need to be explored, such as government observer programs.

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Appendix A.

RECOMMENDATIONS FROM PREVIOUS MARINE DEBRIS CONFERENCES AND WORKSHOPS

In 1984, the First International Conference on Marine Debris, the **Workshop on the Fate and Impact of Marine Debris**, provided several conclusions and recommendations that focused on the need for marine debris education programs (Shomura and Yoshida, 1985). The working group on Management Needs recommended placing significant emphasis on public education and that steps specifically be taken to:

1. Work with fisheries organizations and the fishery management councils to develop and carry out comprehensive information and education programs for foreign fishermen, working within the Exclusive Economic Zone, and U.S. fishermen;

2. Work with appropriate national and international organizations to undertake cooperative information and education programs; and

3. Work with relevant industries, such as has been done with elements of the plastics industry, on public education programs.

The working group also noted that 'to encourage the removal of debris from the environment and prevent the discarding of additional debris, positive incentives such as financial rewards for the return of discarded netting material should be considered as should possible negative incentives.' Additional conference recommendations for outreach efforts included recommendations to:

4. Identify and publicize geographic areas where fishing gear is likely to be snagged and lost.

5. Expand existing stranding networks for marine mammals, birds, and turtles, and incorporate examinations for evidence of interactions with debris.

In October 1987, the **North Pacific Rim Fishermen's Conference on Marine Debris**, held in Kailua-Kona, Hawai'i, recognized that 'fishing industries should make every effort to prevent the deterioration of the ocean environment by promoting education programs and initiating procedures which will lead to a reduction of marine debris into the world's oceans' (Alverson and June, 1988). Attending the conference were representatives of the fishing industry from Canada, Japan, the Republic of China, the Republic of Korea, and the United States. Further resolutions to come out of the conference included:

1. Fishing groups participating in the Conference should focus their efforts to encourage other industries contributing to the marine debris problem to become involved in seeking solutions.

2. Fishing groups should be encouraged to promote local programs to further the education of fishermen, port authorities, resource managers, other seafarers, and

the general public regarding the scope, magnitude, and consequences of the growing marine debris problem.

3. Fishing vessel operators in the North Pacific should be encouraged to post in plain view notices to officers and crews that discharge of plastic materials into the oceans is contrary to international law.

In February of 1988, **Oceans of Plastic: A Workshop on Fisheries Generated Marine Debris and Derelict Fishing Gear**, funded by NOAA, was conducted in Portland, Oregon. Fishermen, marine researchers, educators, plastics manufacturers and government representatives from across the United States met to examine ways to reduce fishing related marine debris and to explain new plastic pollution legislation (Alaska Sea Grant, undated). Workshop participants unanimously agreed that more education about the marine debris issue is needed and that different users groups need different types of education. Recommendations for future education programs included:

1. Promulgation of successful programs such as the Port of Newport Refuse Project, as well as information on the consequences of plastic pollution and pertinent information on the Marine Plastic Pollution Research and Control Act, to the fishing industry and other members of the fishing community, such as fish processors and fishing port administrators.

2. Development of a mechanism for the timely delivery of information, as it becomes available, on new technology to cope with or prevent marine plastic pollution. The concept of a national clearinghouse consisting of a network of various government agencies, port authorities, fishermen's associations, and environmental groups was endorsed.

3. Educational programs for the fishing industry should be spearheaded by fishers and other user groups. Sea Grant and other agencies should provide support but should not take leadership away from the fishing industry or others who already are addressing the issue.

In the 1988 **Report of the Interagency Task Force on Persistent Marine Debris** the following recommendations where made by the various U.S. government agencies involvedin the study:

1. Federal Leadership: Federal agencies should provide leadership and continue formal and informal coordination activities related to marine debris with international organizations, state and local governments, private industry, and environmental groups. Federal agencies acknowledge that an effective program is possible only with strong state and local involvement.

2. Federal agencies should continue to participate actively in international forums to reduce persistent marine debris.

3. NOAA should coordinate and disseminate information related to persistent marine debris. NOAA should call at least two meetings of appropriate federal agencies each year to discuss each agency's education, regulatory and research programs, and to ensure that a continued coordinated effort is made to maximize the effect of existing federal programs.

4. Public Awareness/Education Program: Concerned federal agencies should work with each other, state and local governments, private industry, and environmental groups to develop comprehensive educational materials on problems caused by marine debris and on ways to solve those problems.

5. Federal agencies should cooperatively support a major public awareness campaign by providing seed money and encouraging funding by the private sector.

6. The U.S. Coast Guard, U.S. Navy, and other federal agencies should include material relative to persistent marine debris problems in all educational material for employees and candidates for licenses.

7. Federal agencies should use all appropriate media to explain both problems marine debris causes and proper disposal methods. Federal agencies should support formation of an interagency information exchange system for available educational materials.

8. The U.S. Coast Guard should begin a public education campaign on the requirements of the Marine Plastic Pollution Research and Control Act as soon as possible to assure that owners and operators of all vessels, ports, and the boating public are aware of requirements prior to enforcement.

9. Beach Cleanup and Monitoring: Federal agencies should work cooperatively among themselves, as well as with state agencies, private industry, and environmental groups to remove marine debris from beaches and other parts of the marine environment. Federal agencies should encourage coordination with state and local authorities for conducting systematic monitoring of marine debris accumulation and impacts in order to assess compliance with regulations prohibiting disposal of plastics and controlling other solid waste discharges into U.S. waters.

10. Federal agencies should support local volunteer beach cleanup efforts as well as the collection and interpretation of data on materials that the volunteers remove. Federal managers should encourage employees to participate in volunteer clean-ups.

In April 1989, the **Second International Conference on Marine Debris** was held in Honolulu, Hawai'i. The Report of the working group on Marine Debris Education contains these recommendations (O'Hara, 1990):

1. New marine debris outreach programs should be conducted for new audiences including the packaging industry; municipal sewage treatment operators; government officials and enforcement agencies; coastal tourist industries; tackle manufacturers; operators of small ports, docks, marinas, and yacht clubs; suppliers of stores for vessels; boat manufacturers; employees of retail stores (including fast-food and convenience stores, and fishing and boating stores); environmental and conservation organizations; the media; employees of shipyards; longshoremen; and coastal hunters.

2. A public awareness campaign should be developed that uses the media to effectively disseminate educational information. In developing this campaign an initial assessment of human behavior and public perception of the marine debris problem needs to be made.

3. Dissemination of educational materials could be facilitated with assistance from established education organizations such as the National Marine Educators Association; existing government distribution mechanisms such as licensing and registration procedures for fishing and boating.

4. Specific international agencies such as the United Nations Environmental Programme, Food and Agriculture Organization, and the International Maritime Organization should be encouraged to take part in information exchange.

5. There is a need to evaluate the success of educational programs. Mechanisms such as formal surveys, monitoring of beach debris, and monitoring of shore side refuse reception facilities should be put in place to assess changes in attitude and behavior.

6. The following educational approaches were endorsed:

   - involve members of the target audience in the development of educational materials and distribution;
   - be familiar with the audience and personalize the message to specific target audiences, keeping the information as locally relevant as possible;
   - make educational experiences positive and enjoyable; highlight positive steps taken by groups or individuals to reduce marine debris; and
   - emphasize the benefits to a group for their involvement in efforts to reduce marine debris, including, where appropriate, economic impacts.

Other conclusions of the conference identified the need for:

1. Broad international acceptance and implementation of the terms of MARPOL (73/78) Annex V, especially the provision of port reception facilities.

2. Recognition of the marine debris problem as a symptom of the worldwide solid waste disposal crisis.

3. Expansion of marine debris and solid waste disposal education to people and institutions worldwide, recognizing regional and cultural differences in the perception of these problems.

The **Third International Conference on Marine Debris** held in May 1994 in Miami, Florida produced these recommendations on education and outreach (Coe and Rogers, 1997):

1. Explore the effectiveness of sensational appeals, which aim to reduce marine debris through graphic displays, posters or media campaigns showing animals wounded by debris or through strongly worded slogans about its effects on oceans and wildlife. Consider alternative, more stringent policy measures to reduce debris.

2. Focus on and publicize the problem of combined sewer overflows. Continue research on terrestrial sources of debris.

3. Explore mechanisms to reduce entanglement of marine animals and produce a guide to disentangling and rehabilitation techniques.

4. Establish an impact reporting system to promote and collate observations by beach users, fishermen, oceanographers, scuba divers and others. Start by compiling past records.

Chad Yoshinaga, courtesy of NMFS

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